MANAGEMENT
of an
ENTERPRISE

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by

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Preface

The purpose of this book is to provide the reader with a well-balanced treatment of management essentials. To the extent that such a balance is attained, it is the product of a long process of separating the *more* significant from the *less*. In this field of endeavor, selection involves countless decisions in which one is inevitably guided by his experience and training.

There is no completely logical method of organizing management material. Consequently, we have adopted a sequence of topics that experience has indicated as adaptable to the teaching of the subject. The development proceeds from the tangible to the intangible. It begins with the approach to management decisions, plant location and physical facilities; it ends with organization and top management. The golden threads of management—planning, organization, and controlling—connect successive chapters.

Since the essence of management instruction centers in the problems of application rather than in the mere statement of principles, the adaptation of the latter to realistic situations has been introduced by means of questions, problems and cases. In order to present the important aspects of each topic without confusing the reader with needless detail, the cases and illustrations have been simplified and frequent use has been made of charts.

The writers of this book wish to acknowledge their indebtedness not only to the executives of firms with which they have had contact, but also to their former teachers, Joseph H. Willits, Alfred H. Williams, and the late Richard H. Lansburgh. Moreover, they realize that the body of management knowledge which is the heritage of present day students of the

subject, is the joint result of the experimentation, discussion, and writing of hundreds of executives and management engineers. The writers cannot enumerate or even recall the sources of all the ideas they have accumulated. But, in common with other students of the function of management, they wish to pay homage to a fellow Philadelphian, the late Frederick W. Taylor, whose intellectual honesty and devotion to precise methods have been a strong and continuing influence in the development of industrial management.

The writers are grateful also to those whose painstaking assistance has aided in the preparation of the manuscript, especially to Catherine S. Morton.

Since the material has been developed through classroom use over a quarter of a century, it has been subject to much change and rearrangement. It is hoped that the final result may convey to those not already introduced to business management something of its fascination, and may prove to the initiated both useful and stimulating.

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Section I

FUNDAMENTAL MANAGEMENT DECISIONS

CHAPTER 1

Management—Its Nature and Setting

THE managing of an enterprise is, for many men, a means of earning a living—a mere vocation; for others it is a game featured by strong competition, excitement, and high stakes; for still others it is an opportunity to be of use to their fellow men. Business management is both a vocation and an avocation. Whether a manager is activated by reasons that are purely selfish or by a deep-seated desire to render the livelihood of others more secure depends upon his motives in life. Likely enough he will feel the compulsions of several motives.

What then are the principal management objectives? A brief answer is scarcely possible because the objectives are influenced by human desire and ambition, the age and nature of the business, and the executive's sense of social responsibility. Certainly one objective of nearly all company managements is to keep the company alive, and to maintain its ability to compete. Survival of the firm is of direct interest to the owners and the retention of their jobs is of equal concern to executives (who may or may not be owners). In addition, the owners are interested in the return obtained on their investments—sometimes in immediate dividends, sometimes in long-run appreciation of their investment.

Since profitability, over the long run as well as the short, is of deep concern to those who own private enterprises, it becomes a primary goal for those employed to manage them. As a result, the ability to make a profit is one of the primary tests of managerial effectiveness. But merely making money, important as it is to the stockholders and to the financial health of the company, ought not to be looked upon as the dominant goal of management. The desire to make a product that is useful and highly regarded is usually associated with profit making. Management is likely to take great pride in the quality of the product sold, in its performance in use, its durability, and its finish. As the late Professor Wesley C. Mitchell has said: "Making goods and making money are both objective processes, at some points quite distinct from or even opposed to each other; at most points running side by side, concerned with the same objects and supervised by the same men." [1]

In addition, a business management usually has a tremendous interest in keeping up with, or excelling, its competitors. Relative position in the industry is an objective for which it will struggle with all the means at its disposal. To drop to a lower position in the industry will cause it to lose prestige; to advance over a traditional competitor gives it status. The desire to maintain or improve competitive position, so closely associated with pride and ambition, leads sometimes to practices that are anti-social. Yet, it must be recognized as one of the forces which motivate executives.

Whatever their motives, the managers of enterprises of varying size in different industries encounter problems that have many common characteristics. It is natural that managers, by experience and experiment, should have built up a set of guiding principles of general applicability. This is a body of knowledge with which all executives should be familiar. It is equally important to know how it may be applied to specific situations; such application constitutes the art of managing. A competent manager is more than a specialist in the processing techniques of his industry, important as these may be. He must also comprehend the essentials of

[1] Wesley C. Mitchell, *American Economic Review Supplement,* Vol. VI, page 158.

sound management and the art of their application to specific problems.

Nature of management. Management is pervasive. It is to be found in business, of course, and also in many other types of human activity such as governmental departments, religious and educational institutions, and social agencies such as hospitals. Management problems are encountered in the planning of a polar expedition as well as in erecting a new building; they are as prevalent on the campus as in the store or factory. Consequently, managerial skill calls for the application of sound principles and procedures to a great variety of conditions. It demands a thorough understanding of fundamentals and enough experience and judgment to know what particular form of application is required to meet a given situation. Close personal supervision of a small enterprise with only a minimum of paper work may be required; or one may need to organize thousands of fellow men so that they will work together effectively. The difficulties may be primarily financial, or they may be encountered in marketing, or in the development of new products, or in the procuring of satisfactory raw materials, or in the relations between management and employees.

Moreover, management problems are found in small plants as well as large ones. A small plant presents dilemmas just as frequently as a larger one; in fact, it may prove just as challenging an arena for the exercise of managerial talent. The basic principles to be applied are the same, but the procedures and organization are different because of the smaller size and complexity of the small plant. The latter requires procedures that are adequate but as simple as possible, provided that they fill the need; otherwise the expense will be prohibitive.

Management consists of a group of activities that are related to the accomplishment of a desired purpose. Some of these activities have to do with the planning of future operations; some with procuring and directing the people needed for various phases of the work; some with procuring and controlling the use of money, plant, equipment, and materials. Since management activities are diverse, a large number of synonyms are commonly used for the phrase "to manage." Some of these are:

1. To run
2. To operate
3. To direct
4. To administer
5. To conduct
6. To supervise
7. To superintend
8. To boss
9. To discipline
10. To motivate
11. To plan
12. To control

A composite of the shades of meaning reflected in the foregoing synonyms is embodied in the following definition:

> Management is the stimulating, organizing, and directing of human effort to utilize effectively materials and facilities to attain an objective.

Basic elements. A management problem involves some or all of the following four elements: *men*, *money*, *machines*, and *materials*. These elements appear in various combinations in the matters coming before executives for decision. The elements receive greater or less emphasis depending upon the activity in which they appear. The principal activities of most private companies are financing, marketing, and manufacturing. But, in addition, there are a host of activities such as purchasing, inspection, accounting, and personnel relations—each of which requires intelligent direction and coordination with the other activities.

Basic functions. Regardless of the size or nature of the industry or of the firm, a management problem is likely to involve three basic functions: Planning, Organizing, and Controlling.

Planning is preparing for later performance. It involves the making of forecasts based upon certain assumptions. The great virtue of a plan is that it makes the avoiding of difficulties possible by anticipation. But planning is more than trouble insurance. It is the phase of management that enables objectives to be attained by providing, in advance and usually on paper, a program under which the necessary ingredients for accomplishment are provided. There is scarcely a business activity, whether in finance, marketing, or production, that does not call for planning in some degree. The more complex the problem, the more essential is this basic function.

Organizing involves developing the pattern of jobs required for the activities of an enterprise and filling these jobs with properly qualified men and women. Organizing is a prerequisite to assuring the performance of work because the assignment of definite responsibility and authority with clear-cut relationships between jobs is essential for effective group effort. It involves both the design of the organization structure and the matching of jobs with people who have the innate ability, training, and experience to perform the tasks. Manning is therefore one of the human aspects of management, and it requires dealing with people as individuals as well as in groups. Each employee should be guided into his most useful niche, and the key jobs in the organization filled by those properly equipped.

Controlling is the direction and manipulation of affairs and people to achieve a desired end. It means bringing about performance according to plan. It requires the coordination of diverse activities, such as the procuring of materials, the preparation of proper fixtures and tools, and the setting up of the necessary machines. Failure to provide each of these in the proper quantity and at the right time may prevent the fabrication of the desired product. Control is exercised in many ways: by actually doing the work; by direct supervision; by indirect supervision through others. Or, the control may be of the general type associated with the president of the company, or it may consist merely of the potential power typified by a veto used on rare occasions only. If the company is not of the smallest size, control will almost inevitably involve paper work. As orders are passed down the line they will take the form of written memoranda so that subordinates may know precisely what is wanted, who wants it, and when. In the reverse direction flow reports from subordinate to superior (or superiors) indicating the extent to which orders have been carried out and the mission accomplished.

The human side of management. Management must not be thought of, therefore, as dealing only with things; it relates equally to people. Its field is not solely that of tangible objects like dollars of income and expenditure, buildings, machines, tools, and materials; it includes also such intangibles as the desires and feelings of workers and the psychological reactions of customers to changes in product and price. These human aspirations find expression in unions, whose existence, strength, and policies have a sharp impact upon management decisions.

An essential phase of management is the supply of an effective labor force and the maintenance within it of high morale. This is so important, in fact, as to require personnel or industrial relations departments. Moreover, the executive responsible for industrial and labor relations frequently reports directly to the president in companies where his activity is looked upon as a major one. Whether or not a company gives to its personnel relations this recognition of its importance, all executives need to be conscious that most business problems have a human as well as a material side. Even though a particular problem relates to the quality of the inanimate raw material, the imperfections in that material are likely to affect the output and earnings of the company's workers. In fact, material so unsatisfactory as to lead to a lowering of employee "take-home pay" has frequently led to strikes.

Influence of government. It is also important to recognize the extent to which business management and government are interrelated. In times of adversity, business itself has asked for governmental aid in the shape of tariff protection, subsidies, or loans. At other times public sentiment has forced government to adopt measures to protect customers, workers, or investors. Examples are the Pure Food and Drug Act, the Robinson-Patman Act, the Social Security Act, the Fair Labor Standards Act, and the Securities and Exchange Commission. To finance its manifold and growing activities government has increased taxes to the point where they represent a significant item of cost. In a manner of speaking, the government has declared itself a partner with business, or at least of profitable business, and therefore entitled to a share of profits. The effect of all this is to increase enormously the amount of record keeping required of management. Expensive and time-consuming though it be, the resulting improvement in business accounting has been reflected in more information for executives to use in making decisions. Business men should not look upon business and government as inherently antagonistic but rather as interdependent. Business men should therefore consider governmental agencies as part of the milieu in which they must operate.

Other factors influencing management decisions. The phrase "captain of industry" conveys the idea of an executive who is all-powerful within his domain; but war, depression, and labor trouble make it eminently clear that he is not entirely his own boss. He can act only within limits set for him by economic forces, by law, by social custom, and by ethical considerations. Economic forces influence, for good or ill, practically all companies regardless of the quality of their respective managements. Nevertheless the extent to which outside forces may be taken advantage of, or counteracted, reveals the strength of the executives in charge.

Many factors influence the type of problem encountered and the management policies and procedures adapted to meeting them. Among these are the nature of industry, manufacturing process, and product; stability of sales, production, and employment; relative importance of cost items and competitive pressure upon prices.

Nature of industry, manufacturing process, and product. Business concerns are commonly classified according to the kind of service that they render. For example, some are engaged in manufacture, some in finance, in trade, in mining and lumbering, in agriculture, and still others in providing transportation, communication, or some other public utility. The nature of the industry determines the process required to turn out the product. The type of process, in turn, dictates the kind of men needed and the amount and expensiveness of the machinery.

The size of an establishment, itself a function of the nature of the industry, exerts a profound influence on the complexity of management. In a small retail store, the management may be of the "shirt-sleeve" variety, and yet be extremely effective. To direct and control a department store with equal efficiency requires a far more elaborate "system."

Standardization of product is likely to be found in large firms. It leads almost inevitably to mass production, which makes for inflexibility on the one hand, and great manufacturing economies on the other. Since such products as cement and sugar can be graded with accuracy, the resulting uniformity in quality increases price competition and decreases the margin which a manufacturer can secure for converting raw material into finished product. For example, the refiner of cane sugar receives less than one cent a pound for his work.

In contrast, a diversity of products may create a problem of distribution. An outstanding example is found in those concerns selling patent medicine or toilet preparations, or in concerns in which the by-products are many. The two hundred products coming from crude petroleum and the variety of by-products that a meat packer secures from every steer place a premium on large-scale marketing. A 1,000-pound steer furnishes to our butchers only 540 pounds of meat; the remainder must be sold in some other form. To make a profit under such conditions requires a high volume of sales and a management that can exert such tight control over expenses as to shave the few pennies available for running the business out of each dollar of income received. A management of this type must emphasize detail.

Still another outstanding influence upon the management of a plant is the extent to which the manufacturing process is progressive rather than intermittent. The distinction between these two terms is not to be confused with that between analytic and synthetic processes. The analytic type, which may be found in most of the refining and many of the food industries, is usually carried on continuously. However, a synthetic process in which many materials are combined to form a new product, as in the case of soap, paint, cement, and automobiles, may involve either the progressive or intermittent basis.

Nor is progressive manufacture, as used here, to be confused with 24-hour operation. It means rather the steady flow of work through a plant for such time each day as the plant may be operating. Units of the product follow each other through the processes in a continuous stream, in contrast with intermittent manufacture in which batches or lots are moved from one machine to another with frequent interruptions. Under such intermittent or lot manufacture, the lots do not follow each other in the same sequence because they must often wait for storage or processing reasons.

However, when the volume is sufficient, machines may be kept "set up" permanently to perform the same operation on the same product. If it is possible to secure continuous flow operation, many benefits are to be gained. The introduction of new machines is facilitated, the investment in inventory is reduced, the cost of handling is lessened, and—the point of greatest interest here—the whole problem of planning and controlling the flow of production is simplified.

Stability of sales, production, and employment. Closely related to the type of product are the stability of production, the stability of sales, and the stability of employment. In general, irregularities in production originate from two types of causes, seasonal and cyclical. For example, the volume of business done by department stores has relatively little cyclical variation—that is, the effect of the business cycle is relatively small—but it has a seasonal peak during the "Christmas rush" that is tremendous. Likewise, ice-cream production can withstand depression well, but it is subject to violent seasonality.

Seasonality creates for the manager a variety of problems—the increase of inventories during the months of low sales, the need in many plants for installing additional equipment to meet the peak demand, and the vexing job of adjusting the labor force to the changing volume of production. Seasonal fluctuation lessens the use of plant and equipment. In more technical language, the "load factor" is reduced. Still another view of the same problem is that seasonality induces excess capacity and unabsorbed overhead. This is especially true of industries in which goods cannot be made for stock, or in which orders not filled "at once or sooner" will be lost to a competitor. Seasonality of sales likewise creates labor problems. Although many American plants have felt that they have made progress in leveling their production and employment, others, such as department stores and canneries, cannot avoid hiring temporary help. To the management, this means a lowering of efficiency and an increase of supervision; to the employee, hired only to be laid off again, it means poverty and public relief.

The relative importance of cost items. The relative importance of the several types of cost—labor, material, overhead, and distribution—is a determining factor in making management decisions. For instance, a management seeking to reduce costs may well consider such questions as these:

1. What cost factors are the significant ones within the company?
2. Which of the significant items are controllable?

3. How will an attempt to reduce costs in one direction affect the maintenance of balance throughout all phases of company operation?

The first of these questions deals with the separation of the more significant cost factors from the less so that the main attention may be directed toward those management functions whose critical appraisal would yield the largest returns. Identification of these significant items is preferable to an unthinking effort to exert pressure everywhere, or to the blind copying of control measures found advantageous in other firms.

Every company should know the breakdown of its own cost dollar. Ordinarily the significance will be reflected best by relative rather than by absolute amounts. But, even though the proportion of total cost be small, the absolute amount may be large enough to warrant attention, as in the case of a large bank's expenditure for printed forms. What is not always recognized so clearly is the impact of each cost factor upon management activities. For example, a high percentage of labor cost makes labor relations and wage administration of critical importance. Contrast the effect of a 10 per cent wage advance upon coal operators with a labor cost percentage of 65 per cent and upon soap manufacturers with less than 10 per cent. Obviously the lower the percentage of labor cost the more easily a company can provide the expensive portions of an industrial relations program. A retirement plan costing 10 per cent of payroll, or an extra week of "vacation with pay" costing 2 per cent of payroll will be more or less burdensome depending upon this fundamental difference. Moreover, a high percentage of labor cost, if accompanied by the necessary volume, is an invitation to mechanize. And it is in such situations that wage-price relationships are all-important.

Similarly one might trace the impact of high raw material costs, like those in excess of 80 per cent found in meat packing, upon the need for effective purchasing and inventory control. Not only will management place its procurement in strong hands, but it will install the necessary facilities to safeguard its inventories against deterioration, waste, and shrinkages in either physical quantities or in dollars.

Turning from direct costs to fixed overhead, we encounter problems in the fields of both sales and finance. The higher the burden, the more serious are declines in either sales volume or selling price. A reduction in either one shrinks the margin between sales income and variable costs, a margin that becomes more essential as the burden becomes heavier. In short, high fixed overhead is incompatible with flexibility. Moreover, high fixed overhead is associated with heavy bonded indebtedness, especially among the utilities and the railroads. In the main, these have followed a financing policy different from that of most industrial corporations, but even companies in the same industry differ widely as to their policy in this respect.

Competitive pressure upon prices. In the making of profits, no factor is more significant than sales income. The amount of such income turns upon sales volume and unit selling price. Sales volume reflects the desire of customers for the product, together with their purchasing power. The price reflects the scarcity of that commodity and the demand for it. Naturally, the sales income for a given period is the product of the physical volume sold and of the average price per unit, a simple matter of multiplication that means much in actual dollars.

An exceedingly small percentage of decline in selling price may not only represent a sizable decline in sales income, but may be magnified astonishingly when traced to the final net profit. If variable expenses represent 50 cents of each dollar of sales, the contribution left in the business is 50 cents. The total contribution to fixed overhead and profit is the difference between the net sales income of the company and the total variable expenses for the period. Variable expenses, in turn, are those that vary with volume. "Contribution," as thus defined, is a more certain guide than are profits for use in making decisions affecting selling prices and sales volume. A given line of products, or a business as a whole, may be unprofitable but still worth continuing. This concept brings into clear perspective the relative value of different products as revenue producers without the confusion engendered by the distribution of overhead, and by the distinction between overhead and profit. There can be no profit unless overhead is met. To return to the illustration, if 40 cents of the 50 cent contribution were required at a given volume to meet the fixed overhead, then 10 cents would be left for profit. If, however, the price of $1.00 were reduced by 10 per cent to 90 cents, the variable (or out-of-pocket) expense would still be 50 cents, leaving a contribution to the business of only 40 cents. Since this amount is just enough to meet the overhead, there would be no profit whatever.

The setting of selling prices illustrates the pressure upon a management of forces beyond its control. It is here that a business feels the impact of competition—the ruthless pressure of those who make the same or substitute products. Unless a firm's product is unique in some respect such as design or quality, it must be sold for a price in line with the prices quoted by competitors. So in striving for profits and the continued health of the enterprise, management must be eternally awake to the effect of its prices upon its customer good will, its volume, and its profit.

This chapter is intended to orient the reader before he becomes immersed in the specialized phases of management. It has dealt first with the nature of management, its elements and basic functions, and then with the factors and forces with which a management must deal.

Questions:

1. Does the definition of management apply to enterprises that are illegal? to government? to charitable institutions?
2. Are the four management elements equally controllable?
3. Should methods and markets be included among these elements?
4. With the increase of government regulation of business, does the management function in private enterprises decrease in importance?
5. If you were a movie magnate, would you consider the advent of television an uncontrollable force?

CHAPTER 2

Location, Size, and Vertical Integration

EACH enterprise is influenced for good or ill by certain fundamental conditions:

1. The location of its operating units, and the extent to which its activities are centralized or decentralized.
2. The size of the company as a whole and the size of its operating units.
3. The extent to which it is integrated vertically.

These factors determine the nature of the many problems faced by management and influence management's power to solve them. They are so fundamental as to mark the difference between success and failure, between the continuance and death of the firm. To some extent, decision in these matters does not rest with the management but is the result of circumstances, such as an early start in a particular site. Every management should understand the implications of location, size, and extent of integration so that such changes as are possible may be guided in the proper direction.

The selection of a good location for a plant or office requires attention to the general area as well as the specific site. Location may influence the number of customers, as in the case of a retail store, or the availability to a mill of workers, material, power, or water. Paper mills must be near a copious supply of water; aluminum and atomic fission, near cheap hydropower. Hauling charges may also be a prime consideration, as they are for brick yards. Likewise real estate taxes may cause firms to have a competitive advantage or disadvantage;

how satisfactory the labor supply will be depends not only upon the level of prevailing wage rates but also upon labor traditions and efficiency in the area. In short, the test of a location is whether or not it makes available to the enterprise a combination of costs that permits economical and profitable operation.

Industrial centralization and decentralization. The extent to which operations may be decentralized depends upon the geographical locations of the plants themselves and upon the point in the organization at which decisions are made and control is exercised.

Centralization of a firm's production in a single locality characterized manufacturing during the nineteenth century. The process of scattering a firm's physical facilities in different localities began during World War I and was accelerated greatly by World War II. The search for lower costs and other gains has led to increased manufacturing activity in areas far removed from traditional centers. Consequently these old centers now produce a smaller percentage of given products, though not necessarily smaller absolute amounts. Dr. Ralph J. Watkins, Director of Marketing and Research for Dun and Bradstreet, Inc., pointed out in a National Industrial Conference Board meeting that in 1913 western Pennsylvania accounted for 38 per cent of the national output of hot-rolled iron and steel products, but in 1946 it produced only 22 per cent. Yet the absolute amount of its production grew during the interval. He observes that the choice of a new location may turn on changes in technology, raw material costs or availability, labor costs or attitudes, or marketing costs. Among the significant changes in technology are the advent of the railroad, the automobile, and the long-distance transmission of electrical energy.

The foregoing factors have caused industry to initiate new plants in lower-cost areas that were considered to have advantages over the established manufacturing centers. The rate of growth of these younger industrial areas has been greater than in the older, and the result to the nation has been beneficial because the tendency has been toward leveling up rather than leveling down.

Frequently the decentralization of plants is made necessary by some one factor, such as freight rates. This is the case with the American Brake Shoe Company, having 60 plants, the majority of which are very small. Sometimes decentralization is forced upon a company when it cannot enlarge the capacity of its original plant without making its size excessive. The dispersion of the 22 operating plants of the General Electric Company, scattered in a score of states, is explained partly by this and partly by the desire to devote an entire plant to a single product in order to achieve lower costs through concentration of attention on that product.

Sylvania Electric Products, Inc., is a conspicuous example of decentralization of plant as the result of conscious policy. Formed in 1931 through a merger, this maker of radio tubes had three factories, one located at Salem, Massachusetts, and two in Pennsylvania at Emporium and St. Marys, respectively. In the next decade its employment increased from 1,700 to 5,000. Instead of expanding the original plants, four more were acquired of which three were in Massachusetts and one in Pennsylvania. From 1941 to 1948 the number employed increased from 5,000 to about 18,000, but the addition of 19 plants reduced the average number per plant from 760 to 690. The management prefers a plant-size of 500 employees. It thinks that in a factory of that size, the labor efficiency is better than in larger plants because of better leadership. The latter is believed better because the local manager, being at a distance from headquarters, is given more authority than would probably be given to heads of departments in a large factory. This gives the manager greater prestige. Moreover, the living conditions in small towns may be preferable to those in large cities and production stoppages less likely. If an item is produced at more than one location, customers feel more secure against interruptions in deliveries.

One of the most interesting aspects of this problem is the decentralization of operations and of organizational responsibility. Companies of large size, such as General Motors and General Electric, have been forced to decide whether to concentrate manufacturing operations in one huge plant, or to scatter them in separate plants in different localities. On the one hand are the evident difficulties that result when tremendous aggregations of workers, say in excess of 60,000, all work for one employer and in one city. General Electric's community problems would have been serious indeed had it decided years ago to keep all its activities at Schenectady. On the other hand, the scattering of plants in many cities makes the problems of administration more difficult than when the plants are in one city, like those of the Philco Corporation in Philadelphia. Even with modern methods of communication, such as the telautograph, the teletype, and the multiple hook-up telephone, large distances between plants inhibit consultation and coordination.

A company may concentrate in the headquarters office all the executives who decide questions of major policy. Those in the field in sales offices or at the scattered plants dare not act without explicit directions from headquarters. Such concentration makes for close coordination of activities because divisional heads are in close contact with each other. It may make control more certain, provided the orders of headquarters are actually carried out. But the disadvantages are impressive. When emergencies happen in the field, those on the scene cannot act without getting in touch with headquarters. Delays in taking corrective action are inevitable. Worse still, those at headquarters rule upon matters about which they have insufficient knowledge. The information available to those in the field is often not transmitted to headquarters, and unless the top executives travel extensively they become increasingly unaware of what is happening at distant points. To overcome these difficulties, the General Motors Corporation, Kendall Mills, and other companies have decentralized responsibility and authority, with enough over-all control by the central administrative officers to provide coordination.

Size. The problem of size usually is not one over which a given management has exclusive jurisdiction. The active management may have inherited from predecessors a company grown to large size. Even if cumbersome and unwieldy, the management may have to continue to operate it. Or, a company may be small and the rate of growth unspectacular. The management may long for expansion but find it impossible to achieve, at least in the forseeable future. But a management can and should be aware of its optimum size and determine its plans and policies accordingly.

Size must be considered both in respect to the company as a whole and to its separate plants. The former has been called "scale of administration" and the latter "scale of production." The former affects the ability of a company to deal with other companies. The larger the corporation, the more weight it can bring to bear in its purchasing and selling, and the more able it is to secure additional financing or to carry on litigation. An increase in the scale of administration leads to trading advantages and to pecuniary gains.

Scale of production, on the other hand, yields advantages of another sort. A certain minimum size is necessary to permit the most effective labor specialization and the accompanying use of labor-saving equipment. A plant cannot be said to have reached the optimum scale of production for its industry unless it is large enough to permit the installation of the most up-to-date equipment, because without automatic equipment its production costs will not be reduced to a minimum.

But the problem of the size of a company or plant cannot be studied apart from its industry, because the nature of the product and the technology of the process are determining factors. If dominated by style, the product tends to be turned out by small firms; this will also be the case if the transportation costs are heavy relative to total costs, as with brick. If the power requirements are heavy as in copper, zinc and lead smelting, blast furnace operation, and pulp mills, the enterprises tend to be large.

Size influences profits and costs in varied ways. In automobile manufacture, it would seem that the bigger the company the better. In any case, the small companies that turned out assembled cars in the early days of the industry are no longer extant. The chief advantages accruing from size in the automobile industry are marketing strength, often measured by the number of dealers, and financial strength to permit expensive product engineering and retooling.

In the cigarette industry, the large companies have an advantage over the small firms because of the sales strength gained from costly, nation-wide advertising. Financial resources also provide bargaining strength in dealing with the growers of tobacco. However, it must not be assumed that the impact of increasing size upon costs is always in the same direction. On the one hand, in the bottling of soft drinks, it appears from the industry data that all costs per case for labor, overhead and delivery tend to fall as the number of cases increases. On the other hand, among the job printers, although the over-all effect of increasing size improves the profit ratios, production costs are affected adversely.

There is no question, however, that the size of the plant can be too large. Once the capacity is reached which permits the introduction of the latest cost-reducing equipment, then personnel and other difficulties tend to make the plant less effective. The scale of administration of a company may also be so great that the organizational difficulties of coordination, close control, and quick decision may prove a handicap. In government as well as in industry, management needs to guard against size in excess of the optimum and discover how to offset, by decentralizing control, the inefficiencies introduced by large size.

To be of the right size requires attention to basic design. Just as nature designs a giraffe in a peculiar fashion to provide stability as well as speed, so she equips the rhinoceros with armor-plate hide as a protection and thick legs to sustain his weight. In cold climates she sees that animals have enough mass to stand low temperatures, since very small mammals have too little mass in relation to surface, as J. B. S. Haldane has pointed out in his intriguing article "On Being the Right Size."

In recent years the problems of "small business" have become the concern of politics as well as of management. Small businessmen are numerous, and therefore evidences of political affection for them are understandable. It is estimated by the Committee for Economic Development that 98 per cent of the business units in this country have fewer than fifty employees.

The majority of management questions coming before these small business managers for decision do not differ fundamentally from those which face the managers of large enterprises. Both must deal with matters of financing, purchasing, selling, and so forth. Nor do the principles of sound management differ. It is their application that is affected by size. A procedure that is appropriate for a large hotel chain may be overly elaborate for a boarding house. Also the small firm lacks the specialized talent and the resources to overcome certain problems as well as the large corporation does. For example, it is not practicable for a little company to comply with the elaborate requirements of the Securities and Exchange Commission in order to place its securities on the open market. It must frequently seek some one individual or institution that is willing to make an investment.

In the past, a firm could grow by "ploughing back" its earnings; now, because of heavier taxes, it cannot accumulate capital so rapidly. If the little firm has a good year, a substantial part of its net income is shared with the government; if it has a bad year, the loss must be borne alone. As a result, "venture capital" tends to be diverted from the starting of new enterprises. Yet the nation, like a forest, needs to have new growth coming along. Without these new ventures consumers lack the beneficent competition of these new firms, and job seekers have less freedom of choice. And so the cultivation and protection of small enterprises, especially young ones, is of national concern. But it is debatable whether it is proper to speak of their management problems as being distinct from those of their larger brothers.

In the main the management principles and basic problems are the same; the application of the principles naturally must reflect size as well as other factors present in a given situation. All of this merely means that the working out of procedures calls for individual tailoring to fit the needs of the particular firm, and that a ready-made procedure copied from some unlike situation is likely to be ineffective. Such tailoring is characteristic of good management in a company of any size.

Vertical integration. The problem of whether or not to integrate is fundamental to much of management. To integrate vertically is to bring additional steps in the process of manufacturing and selling under the direction of a single management.[1] Such integration forges a chain of dissimilar processes. It may mean integrating backward toward the raw material, as when an auto company acquires its own steel-making facilities, or a steel mill its own transportation facilities or its own mine. It may mean integrating forward toward the customer, as when a manufacturer of cloth acquires a plant to cut dresses, or when a shoe manufacturer opens retail outlets for his product. Of the two types, forward integration is likely to prove the more difficult to accomplish because of the merchandising and selling problems encountered.[2]

The fundamental management advantage from integration

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[1] Horizontal combination, not considered here, means to bring additional mills or departments making identical products under a single control. An example is a cotton spinner with a number of mills all spinning cotton sales yarn.

[2] Hiram S. Davis, George W. Taylor, C. Canby Balderston, Anne Bezanson, *Vertical Integration in the Textile Industries*, page 2. Philadelphia: published by the Industrial Research Department, Wharton School of Finance and Commerce, University of Pennsylvania, and The Textile Foundation, Inc., 1938.

is more precise control because the different processes can be coordinated to avoid misdirected production. Non-integrated cotton mills do not enjoy this advantage; they are subjected to the speculative effects of a series of intermediate markets for raw cotton, yarn, gray cloth, and finished goods.

Companies have been led to further integration by considerations such as decreased operating costs and greater stability of operations; additional profit margins; and control of quality, supplies, or markets.

Costs may be reduced through the elimination of handling and sales expense at the intermediate stages of production. Moreover, it is possible to coordinate the production schedules of different departments so that they may be operated more nearly at capacity and thus reduce overhead. An example is the purchase of cord mills by rubber tire companies.

The desire to gain for oneself the profit supposedly earned by one's supplier has tempted many a heavy user to "buy out" his source of supply and thus gain "a double profit." For instance, big manufacturers went into the weaving of the fabrics needed for their bags when the weaving of such gray cloth was profitable.

The control of an earlier process increases the assurance of an adequate supply of satisfactory raw material. The Disston Saw Company makes its own steel. The scarcity of steel and of castings following the end of World War II caused automobile manufacturers and other large users to purchase foundries and even steel mills. A company may sell products at two different stages of completion, such as cotton yarns and towels, by means of forward integration. Varying the percentage of product sold at each stage provides a means of securing flexibility.

Some of the significant difficulties involved in gaining the foregoing advantages are: cost of breaking into a new field; increasing inventory and style risks; inflexibility; and restrictions upon variety of product offered.

To acquire the "know-how" essential to success is difficult enough when taking on an unfamiliar process in connection with backward integration. But these problems are technical and can be surmounted if appropriate talent is hired. To integrate forward, however, brings one into severe competitive problems. If a large denim producer made overalls, the resentment of existing overall makers would have an adverse effect on the sale of the balance of its cloth. Again, a spinning mill becomes an unwanted intruder in unfamiliar territory when it undertakes to weave cloth and assumes the problems of distributing that cloth.

Since integration extends the time interval during which a company owns material, it makes large inventory gains in a period of rising prices, but during a decline suffers greater inventory shrinkages. It is in a less flexible position than its competitor that specializes in a single process and is less able to lighten its inventory position quickly. These difficulties become especially pronounced with products that involve style risks. A maker of women's shoes would be in greater danger than a maker of men's were he to integrate forward by opening sales outlets as Nunn-Bush has done. An integrated company can only minimize style risks by forecasting style changes, and the forecast may prove wrong; a non-integrated firm can shift part of its style risks to others.

Greater inflexibility lessens the ability of an integrated firm to adjust to new conditions quickly. In the view of the Industrial Research Department of the Wharton School, this limitation is the most fundamental of all. A large, vertically-integrated company like the United States Steel Corporation cannot change direction as quickly as a company less fully integrated. Owning extensive properties and being forced to bear the resultant overhead, such a corporation cannot take full advantage of any low prices available in the market. In a time of scarcity and rising prices, however, it has the very real advantage of an assured supply when others must be content with their share of a scarce supply. To offset the risk of inflexibility, many companies when integrating backward restrict the capacity at each stage to only part of the normal requirements of the stage ahead. Such a policy, which may be designated as "backward taper of capacity," means that a company will make only part of its needs and buy the remainder in the open market. The departments or mills that are owned can be fully operated, and the burden of fluctuating volume can be shifted to outside suppliers as long as they will provide a ready market.

The final difficulty is primarily a market one. Customers want variety. To be successful a store must provide more variety than a single manufacturer can supply. Likewise a cutter of dresses, if limited to fabrics that his own weaving mills are making at the moment, may find himself outsold by competing garment manufacturers.

To summarize, the decision as to whether or not to integrate is basic to the determination of the amount of capacity to provide, the nature of the processes, and the type of organization. The greater the integration the greater the control over operations, but in such a case the risks from inventory and style changes are also greater. Backward integration is easier to accomplish than integration toward the consumer, but both types lead to inflexibility, which increases the losses in bad years despite the obvious advantages in prosperous ones.

Questions:

1. Why might an automobile manufacturer develop a branch assembly plant?

2. How have advances in the art of communication affected decisions as to decentralization of plants?

3. What is the effect of an undistributed profits tax upon company growth?

4. What management problems are faced by a large company that are not faced by a small one?

5. Was the integration of the Ford Company of the forward or backward type?

CHAPTER 3

Approaches to Management Decisions

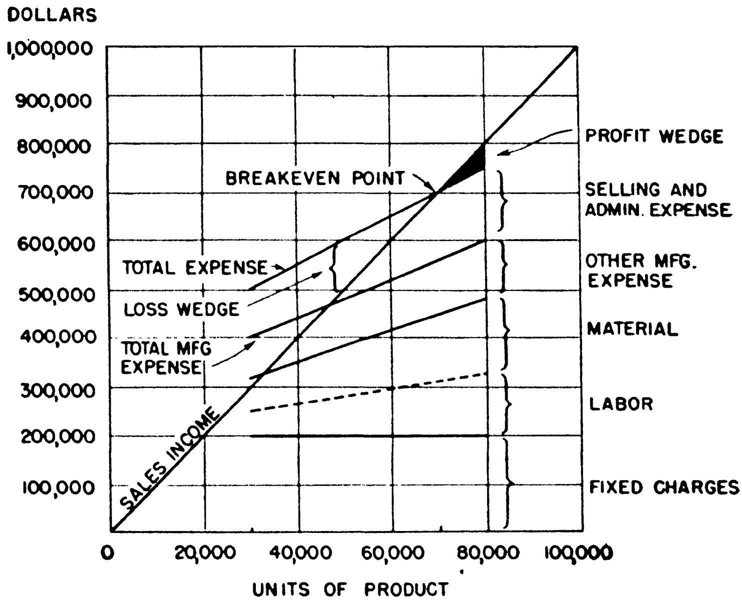
THE making of decisions is the focal point of management. Some decisions are routine in that they are guided by company tradition and practice, or by policies established in the past. Other decisions give deep concern to their originators because of their fundamental significance to the future of the business. To such decisions an executive needs to bring common sense, judgment born of experience, all of his knowledge concerning the outside forces that play upon his enterprise, and the fundamental nature of the enterprise itself. But for most companies the factual information is boundless—so voluminous that some device is needed to bring diverse data into sharp focus in one comprehensive and graphic picture. The best answer to this need is the "break-even" chart.

Break-even chart. A break-even chart portrays in graphic form the relation of volume of production and sales to income and expenditure. Thus it shows the impact of changing volume upon income, outgo, and profit or loss. It shows the effect of price change upon the volume needed to break even and upon profit or loss and it shows the relative importance of the principal items of cost and how they vary with volume. It may be drawn to reflect the data relating to the past or the budgeted figures relating to the future. And, most important, it reduces to one sheet of paper the factual information reflecting past operations or those under consideration.

Ordinarily, devices and procedures are less significant than policies and should be subordinated accordingly in a management text. This particular device is such an important aid in approaching the more difficult and far reaching decisions facing business executives as to merit a thorough understanding.

BREAKEVEN CHART

(MONTHLY BUDGET DATA)



Monthly Budget Data	Low Volume	High Volume
Number of units	30,000	80,000
Sales income @ $10 per unit	300,000	800,000
Fixed charges	200,000	200,000
Material	60,000	160,000
Labor	60,000	120,000
Other manufacturing expense	80,000	120,000
Total manufacturing expense	400,000	600,000
Selling and administrative expense	100,000	150,000
Total expense	500,000	750,000

Chart I.

It will not render decision-making automatic however; the decision will usually require a balancing of the tangible facts with the intangibles. Moreover the executive must usually take calculated risks because of the elements of the problem that are unknown and that defy the getting of reliable facts.

The customary form of the break-even chart (see Chart I) is one with volume plotted in physical units along the horizontal axis, the abscissa, and income and expense plotted in dollars along the vertical axis, the ordinate. The period of time to which the chart applies is usually a year, but may be a month or quarter.

The line representing total income at the average price per unit is drawn from the lower left-hand corner of the chart, i.e., zero on both scales, to a point reflecting the income derived from some high volume such as that considered to represent capacity operation. So long as the average price per unit remains unchanged, this line will remain valid.

The line representing total cost is not drawn so easily. It must be built up from data representing at least two volumes that are far enough apart to give confidence that the slope of the line through them is valid. For instance, cost data for two volumes such as 50,000 units and 60,000 units would not provide as reliable a total cost line as would 50,000 and 100,000. Naturally if data are available for more than two different volumes the results are even more trustworthy because the total cost line would then be based upon several points rather than two. One of the essentials, however, is that all the data represent the same price and cost situation. If the cost data are the actual figures of two successive years during which the wage rates, raw material prices and selling prices had remained unchanged, they would be used without modification. If, however, wage rates and material prices had risen 10 per cent between the two years it would be necessary to add 10 per cent to the data for the earlier year.

Preparation. In plotting the cost figures, the data for the several elements of cost are cumulated and the cumulative totals are plotted above the corresponding volumes. If a particular cost item is under analysis, it should be plotted last. i.e., placed on top. Finally, a line drawn through the cumulative totals represents the total cost at various volumes. This line is valid, however, only within the volume range for which data are available; it should not be extrapolated.

The selection of a unit of volume for the base line of the chart frequently presents a problem. Obviously the unit should be one that is unaffected by changes in selling price; otherwise the chart will not be usable for price setting purposes. Sometimes the volume of production and sales can be expressed by a simple unit such as tons of steel, dozen pairs of hosiery, cases of soft drink, watches, patient-days (hospital) or guest-days (hotel). In other cases the variety of the product is so diverse as to require a unit that measures volume indirectly. An example is the use of man-hours of direct labor in a steel-fabricating plant or in a print shop. Obviously the use of such a unit assumes that labor efficiency has remained unchanged during the interval covered by the data.

The most interesting area on the chart focuses on the break-even point where the total income and total cost lines intersect. This is the volume at which there is neither profit nor loss. Extending from it to the right is the profit "wedge," i.e., the area between the total income and total cost lines, and to the left the loss "wedge." For a company to survive depression, the break-even point should be low in relation to plant capacity and normal sales volume; for a company to show excellent earnings in good times, a profit "wedge" that has a wide angle is required.

Uses. The break-even chart shows the effect of volume upon income at a given average price and presents a perfect answer to these important questions relating to price setting:

> How much increase in volume must result from a contemplated decrease in unit price for the company to be as well off as before the decrease?
>
> How much reduction in volume may be suffered after a given price increase without the company being worse off than before the increase?

Chart 1 indicates that the company breaks even at 70,000 units when the unit price is $10.00; after a $1.00 price "cut" to $9.00 per unit the break-even point would be at 87,500 units. Thus to offset a price decline of 10 per cent would require additional volume of 17,500 units or 25 per cent of the previous break-even volume. Conversely an increase in unit price from $10.00 to $11.00 would decrease the break-even point to 58,333, or 16.7 per cent. Naturally, the chart does not help answer the corollary questions as to how much sales volume is actually obtainable at the prices being considered. This question calls for marketing knowledge based upon experience and market research. The break-even chart merely tells how a given change in price will change the point at which a company breaks even and the amount of profit or loss at the proposed price for the volume that the management believes it will obtain.

A second type of use is in the reduction of costs. In the preceding chapter, reference was made to the importance of determining the relative significance of each type of expenditure so that cost reduction efforts may be directed where they count. The break-even chart shows the amount of expense of each type and the influence of volume upon it; it does not indicate whether a particular type of cost will yield savings. The expense may be large, but uncontrollable. To understand its cost situation, however, a management needs to know what part of its total cost is fixed and unrelated to volume as well as the variable expenses that change directly with changes in volume. If a large part of its expense is of the fixed type and not reducible, then it must obtain sufficient volume to carry the high fixed overhead. In such a case, sales promotion will loom large in importance. If a large item of expense varies with volume, its reduction may affect profits as much as would a price increase.

For the break-even chart to reveal the result of a given reduction in expense, whether variable or fixed, the item in question should be plotted last, i.e., placed just under the total cost line. A proposed reduction can then be indicated on the chart and its influence noted on the break-even point and on the profit "wedge."

A third purpose served by the break-even chart is the portrayal of the company budget. Whereas the uses noted to date have reflected figures of the past, this one reflects the figures for a future period. Such a chart indicates on one sheet of paper the budgetary planning for a range of volume, even though the precise volume of sales cannot be forecast. It therefore shows in bold relief what measures the management needs to take if the company results are to be satisfactory, and provides a stimulant to action in time for it to be effective.

The fourth use of this chart relates to proposals for the expansion or contraction of operations. Since such moves, especially if they involve the addition or abandonment of physical facilities, have far-reaching influence on a company, a clear advance picture of their effects is of value in reaching sound decisions. If it is proposed to acquire another company or plant by purchase, or to build an addition, or to reopen a closed mill, or to shut down one that has been operating, break-even charts comparing the company before and after the change are revealing. The proposal, if adopted, may so increase fixed charges as to raise the break-even point dangerously; or it may so widen the profit "wedge" as to make the company prospects much more attractive.

The technique that has just been described for obtaining a simple but comprehensive view of the workings of the company is an aid in making decisions, but it is only a beginning. It is part of the first step of obtaining all the relevant facts. It reduces to a single page data that otherwise might not be viewed in proper perspective. The second step in the actual making of the decision is to unite this factual approach with an appraisal of the intangible factors that are present in the problem. Rarely can all the desired facts be secured; there are almost certain to be phases to be considered without benefit of factual information. The latter may be entirely unavailable, or not available in time or for a reasonable outlay. What, for instance, will be the reaction of customers or of employees; how are competitors likely to respond; or what will be the state of business?

Then there is the decision itself. The responsible executive has to render the decision based on whatever recommendations are available as a result of fact-finding and analysis. It may prove to be sound and profitable; if so his reputation is enhanced. It may prove disastrous and appear unwise and ill-founded; if so, his reputation may suffer even to the point of his dismissal. Nevertheless, an executive's business life is a succession of decisions. As a result of them he is judged and his company gains or loses.

Once the decision has been made it must be transmitted to others for execution and then followed up so that the performance determined upon will be insured. But this step anticipates a phase of management discussed later on, namely, organization.

In this chapter, the break-even chart has been treated as a device to aid in the making of decisions. Its nature and preparation have been described as well as its uses.

The sales dollar analysis. An effective method of quickly spotting expense areas that require executive attention and decision is the sales dollar analysis. Each item of expense in the profit and loss statement is expressed as a percentage of net sales income, or still more simply as cents per sales dollar. The sales dollar for a small company that makes blow-off valves is made up as follows:

Material	27.7¢
Labor	7.2
Shop Overhead	12.5
Selling Expense	29.2
Administrative Expense	11.8
Operating Profit	11.6

Such an analysis shows the executive at a glance whether expenses are encroaching on the rate of profit and reveals the need for tightening managerial control to protect profit objectives. If the actual sales dollar is compared with a standard or budgeted income dollar, the attention of the executive is guided to specific expenses that are "out of line." If the budget figure for labor were 6.0¢ and the actual 7.2¢, the difference calls for examination and action. Moreover, by reducing both rates of income and expense to simple, summary terms the relative significance of each major expense item as a source of economy is kept vividly before the executive. Inasmuch as business profits are fashioned from sales revenue, the sales dollar analysis tends to be more helpful in making executive decisions than the expense dollar analysis in which each item of expense is computed as a percentage of total expenses.

Although the income dollar, which includes non-operating income, is frequently analyzed, such analysis is less useful as a device for controlling operating expenses.

The contribution ratio. The effect on profit possibilities of executive decisions with respect to volume, cost reduction, and selling price can be brought into sharp focus by use of the contribution ratio. The contribution to fixed overhead and profit, foreshortened for convenience to "contribution," is the difference between the net sales income and the total variable expenses. It may be computed for a single unit of product, for a line of product, or for the company as a whole. Out of this margin fixed expenses must first be met; any amount left will be profit. For instance, if variable expenses represent 60 cents of each dollar of sales, the contribution is 40 cents. If, at a given volume, 30 cents of this amount were required to meet the fixed expenses, then 10 cents would be left for profit. The contribution evidently plays an important part in determining profits.

The contribution ratio is the "contribution" expressed as a percentage of the net sales income. To use it effectively the executive must understand the factors that affect it and its relation to volume changes. Like the break-even point, it is affected by a change in selling price and the variable expense ratio, which is the ratio of variable expenses to net sales income. It is not, however, influenced by a change in fixed expenses. Moreover, when the contribution ratio is low, substantial changes in volume are necessary to influence profit or loss materially. In such circumstances, the attempt to increase volume rapidly may cause outlay to exceed receipts temporarily until the increased income from the enlarged volume is actually received, and so a company with limited working capital may find its cash position impaired. When, in contrast, the contribution ratio is very high, relatively small changes in volume produce large profits or losses. A large volume may then mean high profits, an easy cash position, and perhaps a big surplus for a company.

Uses.[1] One use of the contribution ratio is to guide top management in reaching profit-making decisions on general company operations. For instance, a cabinet manufacturer, whose contribution ratio was 15 per cent, operated throughout the year at the break-even point. Review of the situation led to the conclusion that his contribution ratio was too low, inasmuch as intense competition prevented him from securing sufficient additional volume to yield a profit. The relative inelasticity of demand for his product, in turn, made a reduction in selling price futile; it would only have added to his difficulties by reducing the contribution ratio. The only possible method of raising his ratio was by reducing variable expenses. Analysis of these expenses indicated that direct material could be reduced by making more parts in his own plant instead of purchasing them. To do this it became necessary to buy more equipment and to incur additional supervisory expenses resulting in a slight increase in total fixed expense.

[1] The illustrations used have been taken, with modifications, from two stimulating articles by S. A. Peck: "The Managerial Aspect of Controls," *Bulletin, National Association of Cost Accountants,* December 15, 1938, Vol. XX, No. 8, pages 485-487; and "Further Thoughts on the Management Aspect of Accounting Control," *Bulletin, National Association of Cost Accountants,* January 1, 1940, Vol. XXI, No. 9, pages 563, 566.

The final effect, however, gave the manufacturer a contribution ratio of 25 per cent, a drop in his break-even point of 20 per cent, and a net return of 5 per cent on the same dollar volume at which in the previous year he had just broken even.

A second, and more detailed use of the contribution ratio is found in comparing the relative earning power of the products of a company. The contribution ratio and break-even point for each product will provide sound guides for appropriate managerial action with respect to selling price, volume, cost reduction, and distribution of fixed expenses among the products. If, for instance, the contribution ratio of Product A is 17.0 per cent with a sales volume of $59,000 and of Product B, 41 per cent with a volume of $29,000, the volume of Product A may have to be raised to $118,000 to yield as much profit as an increase of $20,000 in Product B. Yet such a doubling of volume may increase production difficulties immeasurably whereas the $20,000 increase in Product B might be accomplished easily.

An illustration of how the use of product contribution ratios may avoid managerial difficulty is found in the experience of a tire company that distributed 30 per cent of its automobile tires through its own dealer organization and 70 per cent through a large auto-supply chain store. To hold the chain-store business for the ensuing year the tire manufacturer reduced by 15 per cent the price of a tire that represented 50 per cent of his sales to the chain. As a result, the break-even point of the manufacturer was increased from $3,600,000 to $4,500,000 with a possible top volume of $5,000,000. It is doubtful whether the executive would have reduced his selling price had he examined the impact of his action on his contribution ratios. Before the price reduction this ratio for dealer tires was 25 per cent, for chain-store tires 15 per cent, and for the whole business, 18 per cent. Following the reduction, the ratios were 25 per cent, 10 per cent, and 14.5 per cent respectively, thus forcing the tire manufacturer to seek very high volume to maintain his profit position. The break-even volume was raised so close to capacity that the situation could be corrected only by heroic managerial effort.

The economy study. Not infrequently the executive must make a decision with respect to plant extension, the purchase of machines, equipment, or new buildings, or other uses of fixed capital. He usually wishes to save expenses and improve his profit position, but he may also be moved by considerations of better service to customers, higher quality of product, or improved working conditions for his employees which cannot be reduced to figures. Whether his choice lies between the existing method and a proposed method or between several proposed alternatives, he will select presumably that method which he believes to be the most economical. For instance, his problem may be the choice between the installation of a power plant to provide both process heat and electric power and a plant to produce heat alone with power purchased from a utility. Again, it may involve the purchase of either a battery of multiple-spindle lathes or several Mult-Au-Matics, or the substitution in a foundry of a sand-cutting machine for the hand preparation of moulding sand. The decision in such cases will be most effective if based on an economy study—a comparative analysis of the expense estimates of two or more alternative programs to determine on grounds of economy the one that should be selected.

The economy study may be made in terms of either increment costs or total costs. In both types the expense estimates are precisely the same. The difference lies entirely in the form of presentation. Increment costs are the expense differences that are incurred in the extension of a program beyond its established pattern. Whether or not to make this extension is determined on the basis of the expense items (and income, if it is a factor) that are directly associated with the expansion rather than on the total expenses of the entire program. In contrast, the total-cost type of economy study is more useful for analyzing proposals that substitute an entirely new expense pattern for the old, or for alternate proposals that offer a variety of new expense patterns. It is better to compare total expense estimates than unit costs because a decision must be based on the relation of total gain to net investment and because the use of unit costs increases the possible error of inaccurate volume predictions.

The principle of increment costs is illustrated in the following simplified computation to determine whether 8 additional floors should be added to a 12-story office building: [2]

Data:	
Present building	
12 stories	
Total investment	$15,900,000
Total income	1,670,000
Total fixed and operating expenses	766,000
Proposed building with 8 additional floors	
Total investment	19.100.000
Total income	2,900.000
Total fixed and operating expenses	1,192,000
Increment investment	3,200,000
Increment income	1,230.000
Increment expenses	426,000
Return on increment investment	804,000
Yield on increment investment	25.1%

The difference in the yield when total income and costs are used is apparent from the following computation:

Total investment	$19,100,000
Total income	2,900,000
Total expenses	1,192,000
Total profit	1,708,000
Return on total investment	8.9%

The foregoing illustration shows that the increment cost study throws into sharper focus the basis for a decision where facilities are being expanded.

The expense estimates. The economy study is a special

[2] Illustration adapted from C. E. Bullinger, *Engineering Economic Analysis*, page 260. New York: McGraw-Hill Book Company, Inc., 1942.

type of analysis. Its unique nature depends on the premise that executive decisions will be most valid if based on the comparison of two or more series of expense estimates that forecast *true* future costs. It is important therefore not to permit a company's established accounting practices to influence the expense items to be included or their amounts. The point is illustrated by the treatment of "sunk" costs in substituting a new for an old machine. The book value of the old equipment may be greater than its "going" or residual value as determined by what it will bring if resold, traded in, or sold for junk. This difference is sunk cost, an amount already incurred that cannot be subsequently prevented by any action of the company. Sunk cost should be ignored in the economy study. It should not be added to the cost of the new machine for it is not a part of the investment in that machine and its addition would anticipate the very decision for which the economy study is being made. For the same reason, the disposal value should not be deducted. Sunk cost arises because of an error in estimating the depreciation period of the machine, because of inability to make an accurate estimate of that period, or by deliberate choice of accounting practice. Not infrequently depreciation is merely a convenient method of writing fixed investment into costs over a period of time. Nor should it be considered a part of the value of the old machine. This will occur if the book value of that machine is taken as its current value. Residual value is the proper present investment in the old equipment to be used in the economy study because it represents the actual sacrifice that will be made if that equipment is replaced. An adjustment of the books to cover sunk cost by charges to the appropriate accounts will be made if the new equipment is purchased. In the executive's final decision to buy or not to buy, sunk cost is one of a number of additional factors that are ultimately weighed with the results of the economy study.

Any period of time can be used for the economy study so long as all expense estimates are related to it. However, for reasons of convenience in making the estimates and in applying the criteria used in interpreting the results of the analysis, the period is usually one year.

If the process or program under consideration is manual, the expense estimates consist entirely of operating costs and include direct and indirect payroll and related costs such as social security and workmen's compensation. If the proposal involves the purchase of equipment, operating costs should be expanded to include maintenance, power, and supplies. In addition, certain fixed expense estimates based on the value of the equipment must be included. These will cover depreciation, interest on the investment, insurance, and taxes. The proper money base for these charges on old equipment is its residual value; on new equipment, its installed cost.

A simple but effective plan of depreciation and one that is widely used in actual practice is the straight-line method. Because of the uncertainty of predicting salvage value, the depreciation rate is frequently applied to the total value of the equipment.

Interest on investment is included among the expense estimates primarily to give proper weight to the different amounts of money invested in alternative equipment. The value base to which this rate is applied must reflect the method of depreciation. If the straight-line method is used, the interest rate should be applied to the average investment over the depreciation period, since the investment in the equipment is obviously shrinking during the period of its use. A simple formula for computing the average investment is:

$$A = \tfrac{1}{2} V \left(\frac{N+1}{N}\right)$$

where A = average value

V = base value of equipment when economy study is made

N = years over which the equipment is depreciated

The rate of interest should reflect the rate of return on capital invested in the business, rather than the rate at which money can be borrowed. Whether money is actually borrowed for the purchase of equipment is irrelevant, since interest is a cost regardless of source of the capital.

Insurance and taxes, if estimated in percentage form, should be applied to the same value base as interest on the investment.

Interpreting the results. The economy study is a generally useful device whenever executive choice of action is based on economy. For simplicity the principles will be developed for proposals involving equipment only. Whether the problem is the substitution of a machine for a manual operation, the choice among two or more machines proposed for the same operation, or the replacement of an old machine with a new and better one, the wisdom of a proposed purchase is determined by relating the estimated net savings to the additional investment entailed. The latter is the amount by which the assets of a company will be increased if the proposed equipment is bought. This extra investment is the amount which must be justified. There are two methods of determining or testing such justification: (1) the repayment period, and (2) the rate of return on the added investment.

The repayment period test is used where rapid machine obsolescence is a factor that may deter the executive in making a decision to buy a new machine. The number of years is computed by dividing the estimated net savings per year into the added investment. The result will be the time in which the savings if *applied* would pay off the added expenditure. It is a method of dramatizing the importance of the savings.

If obsolescence is unimportant, then the test that should be applied is the yield on the added investment. In either case, the computed result has significance only if a standard or yardstick is applied to it. For instance, the fact that savings can repay extra machine investment in 2 years has drastically different meaning if the standard repayment period for pro-

	Engine Lathes			Turret Lathes		
Fixed Expenses:						
Interest 6% of $4,680 (ave. value)	$ 281		6% of $9,900 (ave. value)	$ 594	
Depreciation 20% of $7,800	1,560		10% of $18,000	1,800	
Taxes and insurance 3% of $4,680	140		3% of $9,900	297	
Sub-total		$1,981			$2,691
Operating Expenses:					
Direct labor	$6,650			$3,170	
Social security 1% of direct labor	67			32	
Workmen's compensation 1%	67			32	
Power and supplies	730			395	
Sub-total		$7,514			$3,629
Total		$9,495			$6,320

Net savings	$ 3,175	
Capital increase to be justified	$10,200	
Test 10200/3134	3.2	years for savings to return added investment
Standard	3.0	years

Figure 1. Economy Study

tection against obsolescence is 1 or 3 years: if 1 year is used, the purchase would be ill-advised; if 3 years, it is entirely defensible. So, too, with the return on the added investment: a yield of 6 per cent is inadequate against a usual return of 10 per cent on money invested in the business, but entirely satisfactory, for example, if measured by the return on government bonds.

Application of these procedural and interpretive points is illustrated in Figure 1. The executive was faced with the problem of determining whether one turret lathe should be substituted for two engine lathes. He had the following information:

Present method		
2 engine lathes, installed cost	$24,000	
Original rate of depreciation	10%	(straight-line)
Disposal value	$ 7,800	
Present book value	$12,000	
Expense estimates:		
Interest	6%	
Depreciation	20%	
Taxes and insurance	3%	
Social Security	1%	
Direct labor	$ 6,650	
Workmen's Compensation	1%	
Power and supplies	$ 730	
Proposed method		
1 turret lathe, installed cost	$18,000	
Expense estimates:		
Interest	6%	
Depreciation	10%	
Taxes and insurance	3%	
Social Security	1%	
Direct labor	$ 3,170	
Workmen's Compensation	1%	
Power and supplies	$ 395	

The estimated net savings are $3,134 and the repayment period 3.2 years. Since the standard for repayment was set at 3 years in this case, the strict conclusion from the economy study would be not to make the purchase, but this border-line decision might be influenced by intangible considerations. It should be noted that the sunk cost of $4,200 plays no part in the analysis.

Debated practices. Whether or not certain expense items should be included in the economy study is the subject of vigorous debate among executives and management engineers, but certain conclusions seem sound.

1. *Savings in floor space* associated with proposed equipment should be included in the economy study only if "saved" floor space can be diverted to other use. If released space is not used, it saves nothing, for the costs of such space still continue.

2. *Savings in overhead* should be claimed only if they represent an actual reduction in any or all of the accounts comprising overhead. Merely because it is an accounting convenience to prorate factory overhead as a percentage of direct labor payroll is no reason for claiming that the overhead on direct labor saved by proposed equipment is also saved.

3. *Depreciation* is sometimes excluded from the expense estimates on the ground that the resulting gross savings shown by the study can be applied to show most clearly how soon the proposed equipment will pay for itself. Another school of thought uses the repayment standard to determine the rate of depreciation. Thus if a machine is expected to pay for itself in two years, it would be depreciated at the rate of 50 per cent per year. Any savings shown by the economy study would then be in addition to the standard required. If no savings were shown, the equipment would not meet the repayment period test. The objection to both practices is simply that they distort the comparative cost estimates. These latter do not represent "true" cost estimates and must be interpreted carefully.

4. The consideration of *federal income taxes*, like that of sunk costs, should be segregated from the economy study. They should be taken into account only after the economy

study itself has been completed, and then only if it is clear that savings will be fully reflected in increased profit. As an example of the mishandling of taxes, an executive whose business fell in the 90 per cent tax bracket some few years ago believed that a new paper bag machine priced at $50,000 would actually cost him only $5,000. But even if the machine cost were deductible for tax purposes, tax rates are subject to change. The purpose of the economic study is to assist the executive in making his decision, and to include tax rates in the estimate would be to anticipate the decision.

Limitations. If the limitations of the economy study are not fully recognized by the executive, faulty decisions will follow its use. These limitations are: (1) the economy study is only a *guide* to decisions, not an exact determinant; (2) in reaching his decision the executive must weigh additional intangibles such as product obsolescence and additional tangibles such as federal income taxes, sunk cost, and anticipated sharp declines in the residual value of existing equipment; and (3) the economy study provides a sound guide only if the expense estimates are made carefully and accurately. The latter represent anticipated experience and are therefore subject to the uncertainties of all predictions. Properly interpreted and used, the economy study is an invaluable device that brings into focus for the executive a complex of expense variables.

Questions:

1. If you were appointed receiver of a piano company, how would you identify the problems to which particular attention should be given?
2. In what respects would a breakeven chart be less valid for a single department than for the company as a whole?
3. What problems arise from the increase in breakeven points of many companies following World War II?
4. Can shut-down costs be derived from a breakeven chart?
5. Is a high breakeven point invariably associated with a low contribution ratio?
6. If the disposal value of a machine seems likely to shrink rapidly during the ensuing year, how would the decision to replace this machine be affected?

Section II

PHYSICAL FACILITIES

CHAPTER 4

Space and Equipment Requirements

FULL utilization of capacity is desirable. Physical facilities represent an investment that leads to continuing costs for taxes, interest, insurance, protection, maintenance, and depreciation. These costs are largely fixed./ Therefore, the higher the volume of production attained with given facilities, the lower is the cost per unit of such overhead; conversely, as production falls off there are fewer units over which to spread overhead and unit costs rise. Thus idle capacity may result in "unabsorbed" overhead.

Idle capacity may stem from managerial inefficiency; therefore, executives should watch the extent to which capacity is utilized. Knowledge of idle capacity may enable corrective steps to be taken; advance information as to prospective idle capacity may make possible its prevention. Operating capacity, with which we are concerned, differs from the word capacity as used to describe the number of gallons a tank will hold, the charge a furnace will take, or the size of piece that can be machined on a lathe.

Capacity factor. One measurement of capacity utilization is "capacity factor," which is the ratio of actual use to theoretical capacity. In order to compute such a factor it is first necessary to determine the unit in which capacity will be measured. In some industries the product is sufficiently homogeneous to permit the employment of product units, such as watches, pairs of hose, and automobiles. If the product is less homogeneous, the product unit may have to be supplanted by a simple physical unit such as tons of steel and yards of cloth or by a compound unit such as the guest-day for hotels, the passenger-mile for railways, and man-hours or machine-hours for machine shops. In cases of maximum diversity it may be so difficult to find a common denominator for measurement that management resorts to a composite unit, such as dollars of sales for department stores.

After the unit is selected, the theoretical plant capacity is determined. This determination is beset with difficulties. The theoretical capacity of a plant assumes full round-the-clock operation seldom met in practice. Furthermore, equipment and labor vary in performance; materials vary in quality and workability. Such variables cause actual capacity to differ widely from the theoretical maximum.

In measuring capacity and its utilization, a time interval must be selected. The extent of occupancy of a hotel may be computed for a day, week, month, or year, depending upon the type of off-peak business it is desired to promote. In general, the length of the interval used is influenced by the promptness with which corrective action may be taken. If utilization can be improved quickly—as in renting banquet facilities in a hotel—the time period for which the capacity factor is computed will be short.

Capacity factor is used most widely in "process" industries such as steel, paper, sugar or oil refining, and brewing, where theoretical maximum capacity can be determined with some degree of accuracy. In most companies, however, the difficulties of computing theoretical capacity are so great as to limit the usefulness of the capacity factor.

Load factor. Load factor, a modification of capacity factor, is more generally useful. It is the ratio of actual use to peak use. Its numerator is the same as for capacity factor, its denominator different. Instead of theoretical maximum capacity, the load factor denominator is the peak or maximum output of a past period. This avoids the pitfalls of calculating capacity.

The problems are the same in choosing a unit of measurement and time interval for load factor and capacity factor, but load factor presents a problem of determining the past level that is to be adopted as peak performance. For temporary periods output may be increased by working overtime, by adding shifts, by "farming out" work normally performed, and by delaying repairs and maintenance. Such steps, however, increase output above a level that may be maintained economically for long periods, and levels obtained through such means should be disregarded in selecting the peak. The maximum or peak output chosen should be one achieved under normal conditions, with the customary hours of work, number of shifts, and work force.

Other measures. Less formal indicators of activity may be used. Dollar shipments or sales, number of transactions, number of customers, or kilowatt-hours of power consumption may be compared with those of a week ago, month ago, year ago, or some past period considered as normal or desirable. Accountants reflect capacity utilization in under-absorbed or over-absorbed burden.

Policy questions related to use of capacity. The existence or prospect of idle capacity influences many management decisions. Continuing overhead costs place management under pressure to obtain contribution to overhead and profit; and hence sales promotion and price policies may be affected. The extent to which a concern can afford to provide capacity in excess of immediate needs for future expansion depends upon the costs of carrying the excess land, buildings, or equipment as compared with gains eventually to be realized. Decisions between special-purpose and general-purpose facilities are influenced by the extent to which the type provided can be utilized fully.

Factors influencing space requirements. The provision and utilization of space for factory and office operation involve the determination of the amount of floor space needed. In this determination, attention must be directed to three factors: the articles and services produced; the methods and equipment used; and amount of equipment necessary. This is true for both office and factory operations. If, for example, a textile mill decides to make a complete analysis of its sales records, the correct quantity of tabulating equipment (card punches, sorting machines, and tabulating machines) and a correspondingly adequate amount of floor space must be provided. Or, if a maker of window-sash pulleys needs five punch presses to punch, shape, and trim the "dials" (or sides), and each punch press requires 50 square feet of working space, a total area of 250 square feet must be furnished. It should be recognized, however, that such a manufacturer will not find it advantageous to make all types of pulleys, nor will every textile mill wanting a sales analysis find it expedient to do the job itself.

An important problem, then, that must be met by executive decision is which products, parts, or services will be produced directly by the operating company, and which will be purchased from others.

In actual practice, even manufacturers in the same industry reach decisions that differ widely. At one extreme, the Ford Motor Company has made most of the parts of its automobile (bodies, wheels, and a few other items excepted), and has produced many of the basic materials used, such as steel, glass and rubber; at the other, some of the smaller independents purchase most of their parts from parts manufacturers, and, with the exception of a new-comer with its steel connections—Kaiser-Frazer—have not extended back to basic raw materials. A manufacturer of upholstery may spin, twist, and dye the cotton yarn, and weave and finish the fabric, or he may buy the yarn, and weave and finish the cloth himself.

The business executive, in reaching a decision on this point, will be influenced by a number of important factors. Among these are the financial condition of his company, the engineering talent at his command, the manufacturing skill of his executive staff and workmen, the suitability of existing equipment, and the amount of idle capacity. His decision will finally hinge upon a comparison of the cost at which the part, product, or service may be produced with the price for which it can be purchased. Furthermore, the need for such comparison recurs throughout the life of the company. The mere fact that a certain part has been produced in the past does not imply that its production should continue, and an alert manager will check continuously the relative costs of making versus buying, using the economy study approach. As a result, not only will manufacturers in the same industry reach decisions that differ widely, but the same manufacturer will arrive at different decisions at different times as the relative influence of the factors changes.

Choice of equipment. After deciding what product is to be made, the executive must then determine the methods and equipment to be used in making it. The term "equipment" includes machines, tools, desks, workbenches, and similar items.

Since equipment problems are affected by the process of manufacture (operations, methods, and so forth), the kind of equipment to be used can be determined only after a detailed study of operations and methods. Such an analysis should be made, of course, by technicians familiar with office and shop devices. The questions to be faced are legion. Shall parts and products be manufactured intermittently, that is, in lots or batches? Or shall goods be processed by progressive manufacture? To what extent shall the principle of division of labor be applied? Will a wider application lead to the introduction of more machines? Can operations be eliminated entirely? Will a change of a part or of material permit the utilization of more economical machines and methods? What mechanical devices may be used? These considerations all influence the kind and quantity of equipment to be bought. Once such questions have been decided, the management can then determine the operations required to make each part and the order in which they should be performed. For instance, the operations through which a nail hammer would pass are shown in Figure 2.

Sequence of Operations	Name of Operation
1	Forge Hammer
2	Heat-Treat
3	Grind Sides
4	Split Claw
5	Burr Claw
6	Grind Back
7	Grind Face
8	Skin Face and Chamfer
9	Scribe Eye
10	File Claw
11	File Eye
12	Bevel Claw
13	File Head
14	Burr Eye
15	File Neck
16	Temper
17	Rough-Polish Sides, Back, under Eye, and Claw
18	Oil-Polish Sides, Back, and Pole
19	Paint and Bake
20	Rough-Polish after Baking
21	Oil-Polish after Baking

Figure 2. Simplified Process Chart for Manufacture of Nail Hammer

The choice of the most suitable equipment requires technical knowledge and close attention to mechanical features, as well as an understanding of four basic tendencies. These are:

1. An ever-increasing extension of mechanical methods of doing work.

2. An increase of semi-automatic and automatic devices where machines are already in use.

3. An increasing adoption of general-purpose or standard machines with special-purpose equipment.

4. A widening utilization of the principle of progressive manufacture, technically known as "simultation."

Increased mechanization. The encroachment of the machine on the domain of human effort is too obvious to require much elaboration. The familiar automatic toaster, thermostatically controlled oil burner, manless elevator, and electric refrigerator represent a development that has its counterpart in industry. The work of the clerks who formerly called off and recorded the readings on metered telephone service has been eliminated by the introduction of the camera, whose eye permits of no error. The work of the accounts receivable clerks in many department stores is being eliminated by the introduction of the photographic process. The resulting increase in the tempo of production implies, of course, greater output per square foot of factory and office floor space. Handling materials and forms affords abundant opportunities for mechanization. The trucker pushing material around the factory sees the substitution of a wide variety of power-driven trucks, cranes, moving belts, monorails, and other types of material-handling devices. The fleetest messenger boy in the office is no match for the startling speed of the pneumatic tube, the telautograph, and the teletype. Distance between the departments and operations is no longer an obstacle either to material transportation or to control of work.

Automaticity. Nor does the process stop with the mere introduction of the machine, for there is a continual attack on the residual human effort required for its manipulation. The trend toward automaticity is unmistakable. A striking example of the trend toward automaticity is the rotary-hearth furnace installed for heating steel ingots in the wheel mill of the Standard Steel Works Division of The Baldwin Locomotive Works. Prior to the installation of this furnace, ingots were heated for blooming in two longneck furnaces, each of which was tended by four helpers who rolled the ingots down the neck and onto the hearths of the furnaces manually. The work of heating was under the direct charge of an additional man. With the new furnace, however, the nine men previously required were replaced by one.

In addition, the operations of charging the furnace and handling heated ingots to the bloom press are now completely controlled by push button. The furnace, which revolves, is first moved to the proper position for charging. An ingot is then centered on the conveyor carrying cold ingots to the furnace, picked off, and deposited at a pre-arranged location in the furnace. The conveyor moves another ingot forward and the process is repeated until the furnace is charged with the desired number of rows. After the first push-button operation, all movements of the charging peel continue automatically until the predetermined number of ingots has been set in the furnace. From the same control station the operator removes heated ingots that have been in the furnace for a complete revolution. The peel picks up the first ingot in the row, withdraws it, and sets it on a plunger raised from a movable platform. The plunger containing the ingot is then depressed and the ingot deposited on the platform that moves into a hydraulic descaler. The descaled ingot is next moved onto the platen of the bloom press and the moving platform automatically returns to receive the second ingot. This is repeated until the whole row is removed from the furnace.

Because of technical difficulties in maintaining required temperatures, the old longneck furnaces could be operated for only two shifts a day with four-hour breaks between. The new rotary-hearth furnace, which maintains temperatures automatically, can be operated around the clock. The substitution of this new equipment increased capacity and improved manpower utilization.

In the textile field, the loom with automatic bobbin-change and automatic stop-motion for broken filling and warp threads has made it possible for one weaver to tend several times as many looms. On accounting machines the automatic decimal alignment, the carriage return, and the card ejectors indicate the same trend. The machine that duplicates tabulating machine cards that have become too worn for use in the sorting machine is another excellent illustration of highly automatic equipment. After a stack of worn cards and a supply of blanks are inserted, the machine completes the operation automatically.

Special-purpose versus general-purpose. Machines may be classified into two groups: special-purpose and general-purpose. The former type, as the name implies, is designed and built to do a specific job. Since its manufacture represents custom work in the machine-builder's plant, the cost of the machine and repair parts is usually higher than that of standard, general-purpose machines. Moreover, its adjustment to variations in product is limited. Consequently, high cost and inflexibility are its principal handicaps.

Despite these disadvantages, many manufacturers making a product of fixed design in large volume have found the use of special-purpose machines highly advantageous. Special-purpose equipment (including buildings) have been used most widely in the metal-cutting and woodworking trades, in fabrication of various plastic substances and in the process industries, such as brewing, flour-milling, baking, and sugar refining.

On the other hand many textile and office machines are of the standard, general-purpose type. Even in metal-cutting shops, there has been an increasing swing toward the latter type. This can be explained in two ways: (1) highly specialized equipment becomes useless if the product is radically changed; and (2) standard machines with special attachments are now so versatile that they may be adapted to many special uses. An excellent example of the latter is the automatic sizing equipment offered for their lathes by The Monarch Machine Tool Company. By means of electronic controls this unit permits perfect duplication of pieces with economical set-up for very small quantities.[1] Such equipment gives "special-purpose" advantages to general-purpose equipment.

Progressive manufacture. The principle of progressive manufacture seeks to perform a series of operations on parts

[1] "Down Go Turning Costs with Monarch," a brochure published by the Monarch Machine Tool Company.

simultaneously. At the completion of an operation, the parts go to a new work station for the next operation. This procedure has the advantage of reducing handling and work-in-process inventories. The best-known illustration of progressive manufacture is the moving-belt assembly line of the automobile industry. This principle has also been built into such machines as the Bullard Mult-Au-Matic. An illustration of both progressive manufacture and the trend toward automaticity is found in the "Transfer-matic" built by The Gross Company, with which one man can machine rear-axle housings for automobiles at the rate of 150 an hour. This machine consists of five independent machine tools synchronized to function together in conjunction with an automatic transfer unit. Twenty axle housings are in the machine at one time—two housings being machined simultaneously at each of the five stations, eight awaiting transfer between stations, and two being loaded or unloaded. The first station rough-bores both ends of two axle housings; the second station finishes the outside diameter of the end flanges and the bolt clearance diameters of the housing adjacent to these flanges; the third station semi-finish-bores the wheel bearing seats; the fourth and fifth stations rough-face and finish-face the end flanges.[2]

The results obtained from the use of such machines are highly important in determining floor space requirements. For instance, one Mult-Au-Matic replaced nine turret lathes in the machining of washing-machine clutch gears, and six Mult-Au-Matics replaced twenty-eight automatic single-spindle lathes in the machining of an automobile part. Five separate machine tools, each tended by an operator, would be required to machine the number of rear-axle housings produced on one of the Transfer-matics described above.

Our interest here is in the relation of these trends to *floor space requirements*. For instance, the introduction of Burroughs bookkeeping machines for posting inventory records

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[2] "High-Speed Machining of Rear-Axle Housings on a 'Transfer-matic.'" *Machinery*, February, 1948 (The Industrial Press, New York).

mechanically may enable three clerks to do the work formerly done by twelve. Thus, entirely different floor area requirements are entailed by this change in method and equipment. In determining the amount of equipment needed, it is necessary to provide productive capacity that is in both external and internal balance.

Productive capacity. The decision as to productive capacity must be based upon anticipated sales volume, hours of work, and rate of production. However, after the necessary capacity has been initially provided, its existence and availability will in turn influence subsequent decisions as to whether to make or buy. External balance is needed to meet sales demand; internal balance, to keep production flowing with "bottleneck" operations eliminated.

External balance. External balance of equipment equates total capacity with a predetermined level of sales volume. In selecting the sales volume against which to balance capacity, total annual sales figures cannot be used, since the volume of sales usually fluctuates during the year. The plant or office should be equipped to take care of this jagged demand curve. If the plant has sufficient facilities to meet the peak sales volume, a large part of these facilities may be idle at intervals. The management may prefer, therefore, to equip the plant for the *average* sales volume expected, and to manufacture and store items in the off-season to meet peak demands. This policy will enable the management to operate its equipment more fully. Or, it may balance its equipment against a sales volume considerably below the peak and fill requirements in excess of capacity by purchasing from other manufacturers, or by delaying deliveries, thus permitting competitors to take the business of customers who are unwilling to wait. In its cotton spinning and weaving mills, Kendall Mills, Inc., is equipped to meet only a portion of its "peak sales." Manufacturers of custom-built products and service establishments, such as restaurants or theaters, customarily provide capacity below peak demand. They can neither produce in off-seasons to meet subsequent peaks nor purchase from others to meet customers' demands in excess of their own capacity. Attaining external balance involves, therefore, a careful study of daily, weekly, seasonal, or cyclical fluctuations in sales volume.

In choosing among the foregoing alternatives, that level of sales should be selected above which it would appear that the long-run advantages of additional capacity would not offset its costs. The decision must take into account a number of intangibles, such as the effect of delayed deliveries.

Internal balance. Internal balance of equipment equates the capacities of successive stages of production. After the decision as to the relationship between productive capacity and sales volume has been made, the problem then becomes one of providing the same capacity at each step in the process. If a machine requires twice as long to perform the first operation as the machine performing the second operation, and four times as long as the machine performing the third operation, it is a matter of simple arithmetic to determine that the ratio of machines required for the three operations is 4:2:1.

Such perfect balance is achieved rarely. The machines actually available for the different operations may not be of the precise capacity to provide a perfect balance. Moreover, the production volume for the plant resulting from the external-balance decision usually leads to fractional machine requirements and makes it impractical to apply the ideal ratio. The same difficulty is encountered in balancing manpower along conveyors. The balancing of such work requires its sub-division so that each operator takes approximately the same time to perform his assigned task, since the conveyor moves the work past all operators at the same speed. If the productive capacity at one stage of the process is insufficient for the volume produced in earlier stages, there results a "bottleneck." If the productive capacity at any stage is so great that it is never fully utilized, there also results unbalance. Although not brought so forcibly to the attention of management, such unused equipment is costly.

Quantity of equipment. If a limited number of items is made on the same equipment, the determination of the number of machines is relatively easy. For instance, if 4,400 bearing cups per eight-hour day are to be produced on a Mult-Au-Matic whose rate of production is 110 per hour, five machines are necessary. But where a great variety of products is made on the same equipment, as in a general machine shop, and where the character of the demand shifts from time to time throughout the year, the problem is more difficult because the machines must be shifted from product to product, involving frequent machine "set-ups." Consequently the volume of each product for a typical week or month, and the typical size of lot for each one, should be used in computing equipment quantities. The total quantity of each type of equipment is the sum of the quantities required for each of the several products, including allowance for the total "set-up" time.

The amount of equipment needed to meet a certain volume is closely related to the hours of work. Obviously, if a manufacturer operates his plant on three eight-hour shifts, he does not need as much equipment for the same sales volume as he would on one shift. Trade practices and managerial policy determine the working hours for plant and office facilities. Twenty-four-hour continuous operation is necessary in certain industries, such as steel mills, blast furnaces, paper and cement mills, and sugar refineries. Some managers, pursued by the specter of the rapid obsolescence of high-priced machinery, think it sound economy to "run the life out of it" as quickly as possible. To minimize the purchase of expensive equipment in achieving internal balance, the management may alter the scheduled hours of work at different stages of production. The machines at one operation may be run ten hours a day to absorb the output of machines on an eight-hour shift elsewhere. In any event, the number of working hours must be known prior to determining the quantity of equipment to be provided.

Finally, the actual rather than the theoretical rate of machine output must be taken into account. As regards manual operators, there is little doubt as to the meaning of this statement, but for machinery the actual rates of output are usually lower than the theoretical rates. For example, if an operator is removing a quarter-inch of metal from the circumference of a steel cylinder 8 inches long on an engine lathe with a spindle speed of 200 revolutions per minute, with a feed of .002 inches per revolution and with one-eighth-inch depth of cut, one part should be finished, theoretically, in twenty minutes—an output of three units per hour. This rate presupposes perfect performance of the machine. However, cutting tools wear, belts slip, and material varies in hardness, and it may actually take twenty-five minutes per unit. This actual production rate of 80 per cent of the theoretical should be used in determining how much equipment is necessary in this case.

To summarize, the steps involved in the calculation of the quantity of equipment necessary and the data required at each step are as follows:

1. List all operations for each product, part, and service produced.
2. List for each operation:
    - *a.* Type of equipment to be used.
    - *b.* Actual production per hour to be expected from that equipment.
    - *c.* Typical volume of work for a given period of time.
3. Calculate required machine hours (*c* divided by *b*).
4. Add total equipment hours required for each kind of equipment.
5. Add to (4) the hours already allowed for set-up or change-over.
6. Determine the quantity of each kind of equipment by dividing total hours required by the hours that a single machine would be in operation.

Computation of floor space requirements. The determination of the products to be made, the processes, and the quantities of equipment pave the way for the decision as to the total floor space requirements. Each machine, desk, and workbench occupies a definite amount of floor area. A double-pedestal desk, for instance, takes a minimum of 14.2 square feet. An additional area of at least 33 by 60 inches should be added for the clerk, making the total area 27.9 square feet. The minimum floor space for a radial drill must take into account the full swing of the head. To this must be added sufficient space for the workman, raw material, finished parts, tool rack, and other auxiliary equipment.

To the total production space, room must be added for the desks of executives and supervisors, as well as for toolrooms, repair shops, stock and supply rooms, locker and rest-room facilities, and shipping and receiving departments. The aggregate space required by all operating and service departments represents the total floor area needed by the business.

Future expansion. Space calculations must take future expansion into account. Under the pressure of competition most enterprises aim at growth, and look upon depressions only as temporary halts in their long-run growth. But the financial burden of excessive floor areas serves to emphasize the difficulties involved in providing for future expansion. All departments seldom expand at the same rate. Thus, without some rational plan of providing additional space for expansion, the general arrangement of buildings may become hopelessly jumbled.

There are five ways in which this problem may be handled:

1. The building may be constructed to permit additions and extensions without affecting the remainder of the structure. For example, foundations and structural members may be made heavy enough to carry extra stories when needed.

2. A shape of building may be selected that permits the addition of wings and adjoining units without disturbing the

existing plant or office arrangement. These shapes may be in the form of **E**, **L**, **H**, **I**, **U**, or **T**.

3. An amount of floor space may be provided greater than is immediately needed. This excess may be distributed among all departments, as in the main office of the Provident Mutual Life Insurance Company, or the interior of a large portion of the building may be left unfinished, as in the home office of the American Central Life Insurance Company at Indianapolis. In either case great care must be exercised in the forecasting of future space requirements, for "carrying costs" must not prove too heavy. In planning new buildings, most companies attempt to forecast their growth over a five- to ten-year period, and provide space accordingly.

4. A constant pressure may be made to economize in the use of space so that activities can be expanded without the addition of floor space. To this end, concerns like the Jewel Tea Company have included savings of floor space as one factor in rating the effectiveness of supervisors. Of course, so long as space released from use remains idle, there is really no saving to the business, but the steady accumulation of such released space may postpone the necessity for additional buildings.

5. A final method followed by many concerns, particularly offices and smaller manufacturing companies, is to move from one location to another at relatively frequent intervals in response to the pressure of growth.

Methods of Acquiring Space

Type of building. The factory or office building is as much an operating tool as is any machine. For this reason it is essential that the building "fit" the processes or activities carried on, and make economical operation possible. Buildings may also be general- or special-purpose (as, for example, breweries). The factor of obsolescence must be weighed carefully because the general-purpose building can be leased more easily and has greater resale value.

Buildings may be further classified into two general types: single and multistory. Sugar refining and flour milling, for instance, require multistory buildings for most economical processing, for gravity is used extensively in moving the material through the progressive stages of manufacture. On the other hand, locomotive and steam turbine manufacturing plants, foundries, cement companies, and similar enterprises using heavy machinery or bulky materials, need single-story structures. Between these extremes lie a vast number of businesses for which either a single or multistory structure will prove satisfactory; for example, mills making full-fashioned hosiery, upholstery, and broad silks.

The factors that determine which of these types should be used are the value of the land and the costs of constructing and of operating the building. Where land values are high, it is usually economical to erect multistory buildings like the towering structures of lower Manhattan. Such sites are obviously too expensive for general manufacturing operations. Not infrequently, however, factory managements must debate the choice of two locations, one of which is of sufficiently high value to justify a multistory building.

The cost of construction ordinarily depends upon the type of structure and the number of floors. Building structures are of three types: mill, reinforced concrete, and structural steel. Multistory buildings require heavy base structures and additional reinforcement in walls, pillars, columns, stairways, and elevator shafts, which increase construction costs, and decrease the floor space available for actual use. Consequently, in choosing between different available land sites and types of buildings, it is always advisable to compare costs on the basis of square feet of net available floor space. A final element influencing construction costs is aesthetic. A building that merely serves a utilitarian purpose may be an ugly blotch, but it is not necessary to erect ornate offices and factories in which the concessions to "art" evidence all too clearly "conspicuous waste." There is no reason why utility and good taste cannot be combined in the design of a building. The question of outward appearance and structural design calls for the services of an architect and a construction engineer. Building designs vary considerably. In buildings like those of the Philadelphia Savings Fund Society, at Twelfth and Market Streets in Philadelphia, and of the McGraw-Hill Book Company in New York City, the modern influence can be clearly seen.

The operating costs of a building include expenses for light, heat, elevator service, and maintenance. These items, in turn, depend upon the materials and design used in construction, heat losses through radiation, and the internal and external wear and tear to which the building is subjected.

Should buildings be purchased, built, or leased? The proper answer to this important question depends upon a number of factors: the amount of working capital available, the relative permanence of location, the trend in construction and operating costs, peculiar construction features required by the business, availability of suitable buildings, and the conditions of rental (that is, the amount and period of time covered, and the type of lease).

Obviously, if the company has only a small amount of capital available and cannot or prefers not to borrow, it will lease rather than build or buy. Moreover, if the location is only temporary or if the company can use its capital in its own operations more effectively than in the construction of a building, leasing is advantageous.

Depressions may call for the contracting of floor area as the volume of business decreases. A plan of staggered leases permits such curtailment, particularly if the firm is located in an office or loft building, or has multiple units such as chain stores. This is a further argument for short-term leases. On the other hand, if finances permit, a period of exceptionally low construction costs might induce a company to buy or build. An argument in favor of the purchase of an existing building rather than the erection of a new structure is the opportunity to buy at a sacrifice price. Even with a large amount of renovation, the total investment in building may be so low as to put the company in an enviable operating position.

A development that many companies are finding advantageous, particularly if they are short of capital, is the long-term lease of buildings specially designed and erected to fit their own needs. The contract may or may not include a purchase option to take over the building at its actual cost plus a nominal profit to the owning corporation.

Questions:

1. Compute the capacity factor for your classroom at the moment.

2. How would the concept of load factor be useful to the operator of a fleet of trucks?

3. How might the load factor prove useful to a management in setting selling prices and in directing sales promotion?

4. If the desired production of bearing cups from the Mult-Au-Matics were 5,500 instead of the 4,400 used in the illustration, how many machines would you buy? What are the alternative solutions?

CHAPTER 5

Layout and Material Handling

THE most effective use of space and equipment is secured only when the equipment is arranged in accordance with the principles of good layout.

Layout situations. The situations encountered in making a layout fall into three categories:

1. The assignment of work to each building in a company with several buildings at a single site.
2. The interdepartmental relationships within a single building.
3. The detailed arrangement of equipment within each department.

Good layout means the arrangement of departments, machines, desks, and other equipment to achieve a smooth and rapid flow of work. If equipment and departments are scattered about chaotically, productive effort is hampered. Profit leaks that are traceable to inadequate layout include inefficiency of direct labor, excessive inventories, higher trucking costs, less effective supervision, and spoilage.

Problems of layout are common to all enterprises. Like the manufacturer, the retailer must place his counters and showcases and arrange his stock upon his shelves. The office manager must locate desks and office equipment. In short, enterprises of all types, even theatres, banks, restaurants, hospitals, hotels, and circuses, must arrange their facilities properly.

Layout problems arise when a company builds and equips a new plant, or when the forces of change make its existing arrangement uneconomical. Only rarely are companies faced with the first situation. When this is the case, the machinery and equipment can be laid out "on paper" in the most economical manner, and the building constructed around the ideal layout. This is desirable especially in processing industries, such as sugar refineries and flour milling. In contrast, the more frequent problem is to adapt the existing building where limitations are imposed because the amount of space and the shape of the building are fixed.

A layout is almost certain to represent a compromise. For example, it will remain ideal only as long as there is no substantial increase or decrease in the rate of production, no basic change in the technology of production, and no changes in the products manufactured. When radical changes in these factors occur, a complete change in the layout will be necessary. Although such fundamental changes are infrequent, minor changes are always occurring. Consequently, the problem of layout is an ever present one that requires continuous attention.

One problem is to fit new equipment into the existing arrangement at the appropriate places. This involves finding the required space at the right place, or if the space is not available, revising the layout. For example, one company bought improved machine tools and found it necessary to change the location of its light-machine shop from the mezzanine to the ground floor because the floor load was heavier than the mezzanine could hold. Not infrequently, a management is tempted to place a newly acquired machine in whatever spot happens to be vacant. While this decision may result in a lower immediate expenditure, it may prove more expensive in the long run, and such a decision is defensible only if based upon an economy study. One may also be forced to compromise because of the limitation imposed by fixed points. These include the walls, reinforcing supports, pillars, stairways, elevators, windows, floor areas—in short all the parts of an existing building that affect the layout, and the alteration of which requires great expense.

Making the Layout

In making a layout it is necessary to keep in mind certain objectives:

1. Proximity of related activities and direct-line flow of work.
2. Short moves with accessibility.
3. Adequate visibility for effective supervision.
4. Flexibility.

Proximity and flow of work. In making a factory or office layout, related activities should be placed in convenient proximity. This is true in locating individual machines and desks as well as departments and service areas. In placing departments it is advantageous to locate the major manufacturing or office activity first, and then to locate other departments in relation to it. In an automobile plant this activity would be the assembly department; in a print shop, the press room; in a steel mill, the furnaces; in the offices of a large railroad, the passenger and freight audit department. Around this major department the others are then clustered in such a way as to promote the efficient flow of work. Each department should be placed so that its product can enter the main department at or near the point of use. For example, in an automobile assembly plant each sub-assembly line enters the final assembly line at the point at which the sub-assembly is needed.

Auxiliary departments should also be placed in convenient relation to the departments they serve. For example, the die-storage department should be located close to the press room where the dies are used. The same principle applies to the location of other auxiliary departments such as tool rooms and inspection centers.

Proximity affects the flow of work. It is usually considered the best practice to have the work flow in a direct line. This means that the work should move through successive work-

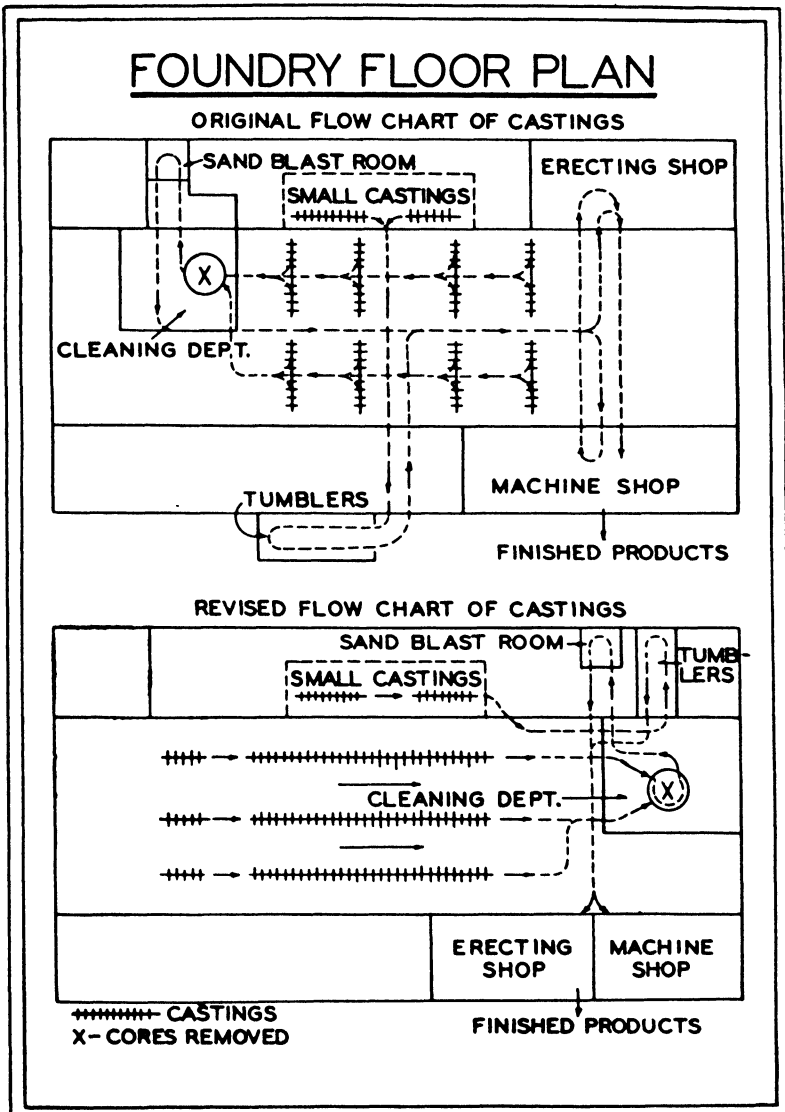


Figure 3.

centers without backtracking. The line of flow need not be exactly straight, but may take a directional pattern such as **E, O, S, or U.** Departments and equipment should therefore be so arranged as to effect a progressively forward movement of the work as is shown in Figures 3 and 4. In multistory buildings the vertical flow may be as important as the horizontal flow. In a sugar refinery the flow is from the top of the building to the ground; in a furniture factory, it is the reverse. In multistory offices, activities requiring close proximity may be placed on adjacent floors if the vertical distance between

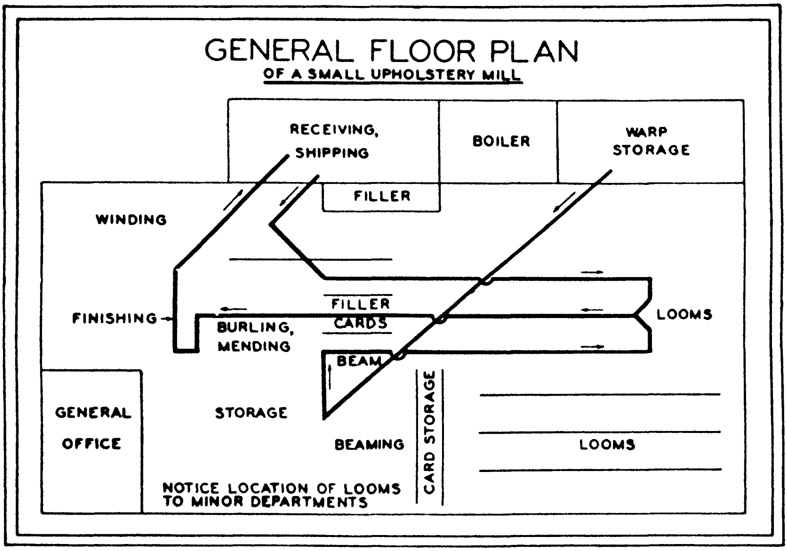


Figure 4.

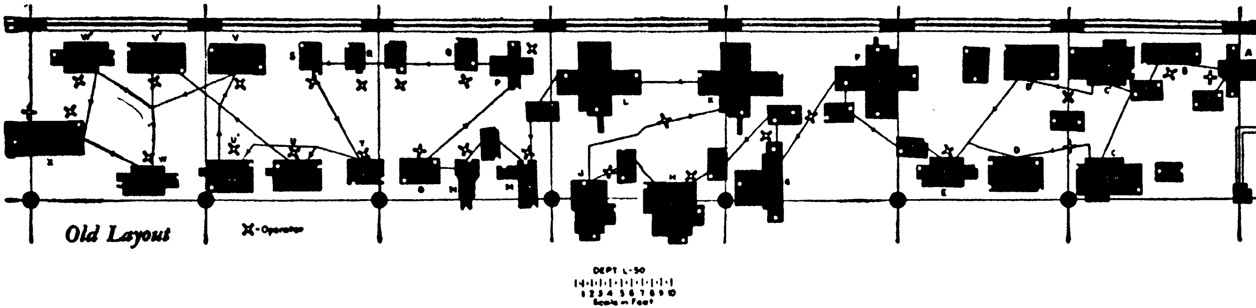
them is shorter than the distance would be if they were on the same horizontal plane.

It is often necessary to compromise with the principle of direct-line flow, not only because of "fixed points," but because operations may require special locations. Forge-shop equipment needs to be on the ground floor because of vibration; the paint shop must be isolated because its contents are inflammable and the spraying operation throws off fumes. Operations may be noisy, as are addressographing and tabulating, or they may be wet, as in a tannery. In the worsted industry, the wool-sorting operation may be placed on the top floor to secure good natural lighting, and the succeeding operation of scouring located on the ground floor because of the weight of the scouring machine. Still another reason for compromising with an ideal flow of work is to avoid the purchase of extra machines. Frequently the same machine is used to perform different operations at different stages of manufacture, and it is cheaper to "backtrack" than to buy an additional machine. The disadvantage of placing an operation outside the direct flow may be offset to some degree by the use of good internal transportation, which links operations cheaply even though they are separated widely.

In general, there are two methods of grouping machinery: by product and by process. This does not mean, however, that one of these methods must be used exclusively in all departments. The grouping of machines by process involves placing of all machines of the same kind together; lathes will be in one group, milling machines in another. In a textile mill, all spinning frames will be placed together, or the looms will be located contiguously in the weave shed. This method has the advantage of requiring less equipment because the same machine may be used for a variety of products if the volume is low or erratic.

The grouping of machines by product requires that all the machines used in making a single part or product are grouped together, and arranged in the order in which they are used. This method, characteristic of mass-production industries in which volume is high, involves the placing of unlike machines together. It results in placing dissimilar machines next to each other. It has the advantage of direct flow of work, minimum handling costs, simplified production control, and better coordination of operations. However, the breakdown of one machine may shut down the entire production line.

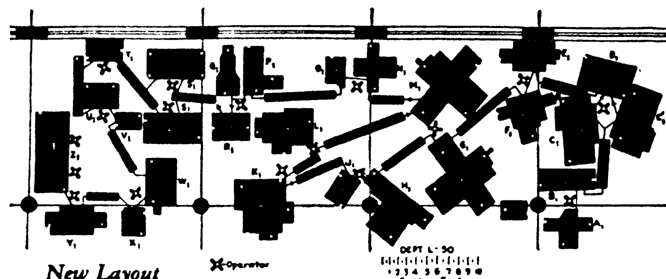
Short moves and accessibility. Good layout involves the effective use of space as well as proper flow. It is possible to achieve direct flow of work at the expense of space, but it is also possible to economize so much in the use of space that the



Layout for a department machining a piece weighing sixteen pounds. Total distance moved is over two hundred feet. Parts are moved from one operation to the next in stock containers on wheels. Sequence of operations is indicated by letters. This layout is typical of usual practice, all machines being lined up parallel with the wall.

KEY TO MACHINES

1.	B. & S. Milling Machine	12	Baker Drill Press	25	Norton Grinder
2.	Centering Machine	13.	24" Cincinnati Drill Press	26	Norton Grinder
3A.	Model R Lo-swing Lathe	14	Edlund Drill Press	27	Rockford Rigidmill
3B.	Model R Low swing Lathe	15.	No. 2 Cincinnati Miller	28.	Taft Pierce Thread Miller
4A.	Lo-swing Lathe	16.	Single Spindle Drill Press	29.	Avey Drill Press
4B.	Lo-swing Lathe	17	Whitney Hand Mill	30.	2-Spindle Edlund Drill Press
5.	Norton Grinder	18.	Whitney Hand Mill	31	Snagging Grinder
6.	48" Hydromatic Miller	19	Whitney Hand Mill	32.	Wet Grinder
7	Cincinnati Miller	20	Taft Pierce Thread Miller	33.	Bench
8.	50-H Baker Drill Press	21	Lees Bradner Thread Miller	34.	Bench
9.	50-H Baker Drill Press	22	Lees Bradner Thread Miller		
10.	48" Hydromatic Miller	23	Bryant Grinder		T—Hand Truck
11	48" Hydromatic Miller	24	Bryant Grinder		C—Chute



How the same department looked after rearrangement. Parts are transferred from one operation to the next by chutes, eliminating all handling. Typical is the change in the grouping of the Lo-swing Lathes. Formerly each operator ran two machines, walking twenty feet for each part machined. In the new layout three machines served by chutes are set in the form of a triangle and run by one operator. Apparent backtracking at operation M_1 is to enable the operator at Machine 6 to run 10 also. Seventeen men now do the work of 27, and several machines have been eliminated. Floor space was reduced 40 per cent. Amount of work in process has been substantially reduced.

Courtesy of "Factory and Industrial Management," December 1931.

Figure 5. Layout Changed to Secure "Short Moves" and Economy of Space.

worker will have insufficient room to work. In developing a layout, the worker should be provided with adequate space for his tools and materials. Workers, supervisors, and service men should have ready access to the work place. One method of attaining this result is to thread the working areas with aisle-ways to enable both operator and material to reach the work place rapidly and without distracting other operators. Usually, it is good practice to have a main aisle, with side aisles branching from it at intervals. Along these aisles machines may be located at such an angle as to make access by truck easy. These aisles should be kept free from materials and equipment to avoid congestion and accidents, and are frequently indicated by lines painted on the floor. When it is desired to increase the number of machines tended by a single operator, the need for short moves increases. A shift in emphasis from flow of work to short moves affects both the arrangement of equipment and the amount of floor space required. See Figure 5.

Visibility for effective supervision. All parts of a working area should be clearly visible to the supervisor. Although he may not remain at his desk constantly, his office should be located so that he can observe from it all persons under his jurisdiction. Operators that are out of sight tend to "soldier." Despite some increase in noise and distraction, the desire for visibility and economy of floor space has caused many companies to adopt the open office.

Flexibility of arrangement. To an increasing extent machines and equipment are being grouped by product. When this is done, changes in the design of the product or in its manufacture involve changes in layout. Therefore provision should be made to minimize the expense and trouble of relocating equipment. The use of unit-motor drive adds to flexibility; even where overhead shafting is used, it is possible to design the overhead structure so that shafting may be changed with little difficulty. Moreover, the cost of moving machines may be reduced 35 per cent to 40 per cent by mounting all electric-drive equipment on the machine itself. Many companies, too, have wired their plants with ample electrical outlets. When frequent changes in layout are required, machine tools may be mounted on skids or designed for moving by lift-truck.

Under the floors of many plants is a grid work of wires and pipes, thus making it possible to connect machines anywhere on the floor area without being unduly restricted by the location of electrical outlets and pipes carrying cutting solution and compressed air.

Influence of internal transportation. No effective layout can be made without careful consideration of the method of internal transportation to be used. This factor has a direct influence in the determination of space requirements and the location of equipment. For example, if trucks are employed, sufficient space around the machines must be provided, and aisles must be wide enough to avoid congestion in moving trucks about. If moving belts are used, from or upon which work is performed in transit, the equipment should be close to these belts. If overhead cranes are used to carry heavy products, space must be provided for the transfer of loads. A large runway, too, should be provided and kept free of equipment, to avoid accidents to machine attendants. Again, if material is carried by an overhead conveyor close to the ceiling, floor space is thereby released and machines may be moved closer together.

Making the layout. Excellent aids for developing a layout are two-dimensional templets and three-dimensional models made to the same scale as the floor plan itself. These templets or models are placed upon the plan and moved from position to position to secure the most desirable arrangement of machinery and equipment. The templets portray not only the area covered by the base of the machine, but such portions of the machine as extend beyond the base. For example, a templet for a radial drill press will include the area covered by the swing of its head.

Three-dimensional models make it possible to visualize the headroom requirements for the various pieces of equipment and portray the final layout realistically. This stimulates suggestions for improvement that might not be evident from two-dimensional templets.

If the factory is multistoried, a model may be created to show the flow of work between floors. Some companies, like the U. S. Rubber Company, retain their layout plans and models so that the location or the relocation of a machine may be studied.

Material Handling

Importance. The term includes both the loading and the unloading of material (material handling proper) and its movement in any direction (internal transportation). Its all-pervading importance in the operation of a plant is sometimes overlooked. Material is delivered to the receiving department and carried to a storage depot where it is handled in the process of stowing it away. Later it is taken out for the initial operation and is then moved from one work station to the next through the entire manufacturing process. Not infrequently, it is moved to a work-in-process storeroom for temporary storage, and, as finished goods, it is taken to a finished-goods storeroom or to the shipping department. Even in a small plant, a single part may be handled many times and the distance it travels may be as great as a mile. Each move is a source of expense and potential point of congestion. In one mass-production plant the material is in transit during 90 per cent of the time necessary to produce it.

One agricultural equipment manufacturer has found that it is necessary to handle 180 tons of material for every ton of finished product. Similarly, a foundryman has estimated that over 67 tons of material and productive equipment must be handled for every ton of good castings produced. To save expense, conveyors are frequently an integral part of the machine. This is true of traveling bake ovens for bread and cakes, of cement kilns, and of Fourdrinier paper machines. This is closely akin to the process conveyor around which producing equipment is arranged.

General methods of transporting material. Material may be moved either interdepartmentally or intradepartmentally. Both are excellent sources of economies. Within each field any or all of the following methods may be used:

1. Moving by operators themselves. Where operations are fast and monotonous and material is light, this method affords a change of pace and a partial rest for the operator. Ordinarily it is not considered good practice.

2. Moving by department truckers or move men, where the volume of work justifies a special labor group. This method lends itself to abuse: too few truckers may cause delay at the machines; too many may cause excessive trucking costs.

3. Moving by centrally controlled truckers operating on a definite schedule. Unless trips are made frequently and sufficient aisle space is provided in the layout, this method may prove inadequate. The size of the plant makes the coordination of intradepartmental and interdepartmental trucking more difficult.

4. Moving by conveyors and other devices that carry the material from operation to operation by mechanical control. This method necessitates a fair degree of rigidity in the flow of work. The greatest economies have been effected by the application of material-handling devices of the mechanical type.

5. Moving by rail or overhead crane. This method, particularly applicable in heavy industries, has the disadvantage of causing loss of employee time when cranes are unavailable. Furthermore this method requires space for transfer areas.

Economies from material-handling equipment. The economies from modern handling equipment are frequently spectacular. The Ferro Machine and Foundry, Inc., used 10 men for 2 hours to load a truck with castings, at a total cost of $20.00, by passing them along one at a time from a push cart.

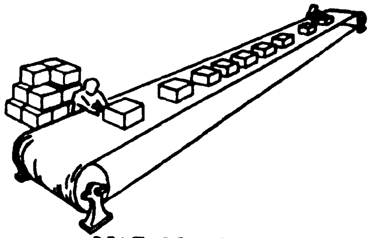
By loading the castings unit-loaded on sixteen pallets, a fork truck performed this operation in one hour at a cost of $1.88. In Chicago, Sherwin-Williams saved $288,000 a year by designing a new warehouse around a coordinated system of conveyors, monorails, fork trucks, and pallets. By rearranging its core-making operation around a conveyor, monorail and pallet system, one Westinghouse plant increased its production 400 per cent. A large grocery warehouse reduced its cost of unloading a box car of coffee sacks from $44.00 to $7.00 by the use of a fork truck. By shipping castings on pallets, a large electrical manufacturer reduced breakage costs from $48.00 a day to a negligible amount.[1] Improved handling methods in the Edison Storage Battery plant have reduced inventories 28 per cent. In the foundry and storage yard of one company the installation of traveling cranes used with clam-shell buckets and lifting magnets made possible a doubling of production, with a reduction of 92 per cent in the labor cost of charging the cupola.

In summary, proper selection and use of material-handling equipment may lead to the following economies:

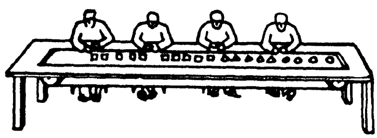
1. The reduction of direct and indirect labor pay roll.
2. The speeding up of the production process, with improvement in the absorption of overhead, the time of filling orders, and service to customers.
3. The reduction of work-in-process inventory, resulting in a more effective turnover of working capital.
4. The conservation of floor space and more effective flow of work.
5. The reduction in the amount of material spoiled or broken.

Indications of need for mechanization. Opportunities for the reduction of handling costs by the application of mechanical devices are suggested by the following situations:

[1] The foregoing cases are referred to in a feature article in *Fortune*, June, 1948, page 96.



BELT CONVEYOR



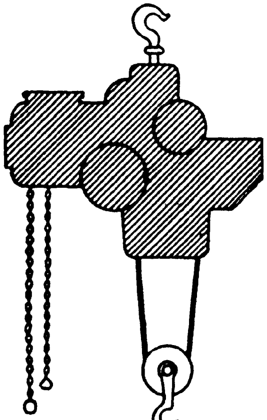
BELT CONVEYOR TABLE

A. POWER DRIVEN EQUIPMENT

1. Conveyors
   Mechanical endless chain
      Apron
      Belt
      Bucket
      Hook

   Pressure tube
      Steam jet
      Pressure pipe lines
      Pneumatic tubes
         Suction
         Blower

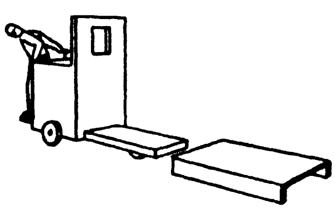
   Power-driven screw



PNEUMATIC HOIST

2. POWER HOIST

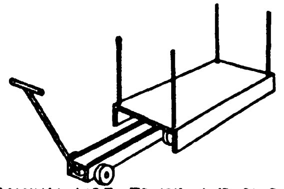
3. OVERHEAD CARRIERS—*between fixed points*
   Cableways
   Monorail
   Cranes
      Overhead traveling
      Cantilever
      Boom
      Pillar



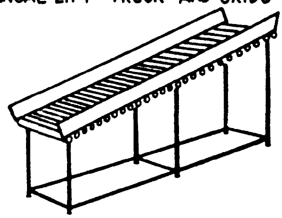
POWER LIFT TRUCK

4. POWER TRUCKS

Figure 6. Classification of Material Handling Equipment.

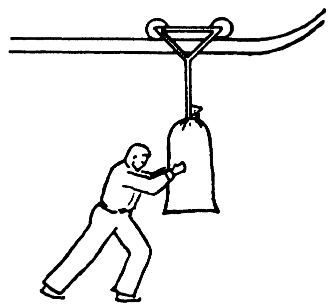


MANUAL LIFT TRUCK AND SKIDS



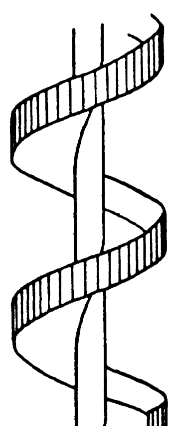
STRAIGHT CHUTE

B. MANUAL EQUIPMENT
- Wheelbarrows
- Trucks
- Hand elevators
- Lift truck and skids
- Overhead monorail



OVERHEAD MONORAIL CARRIER

C. GRAVITY EQUIPMENT
1. Chutes
   - Straight
   - Spiral
2. CONVEYORS
   - Roller
     - Straight
     - Spiral
     - Herringbone
   - Pipe lines



SPIRAL CHUTE

Figure 6 (*Cont'd*).

1. More than one man moves a load manually.
2. One man lifts unit loads of over 100 pounds.
3. Operators wait for material to be brought to them or get it themselves.
4. Material is damaged in handling.
5. Men load from floor to trucks or vice versa.
6. Material is transferred from one container to another.

Classification of equipment. Material-handling equipment may be classified in several ways. One basis of classification is to distinguish between equipment for bulk materials and that for individual units. A second classification is based on mobility, the equipment being divided into portable, self-propelled, and stationary. A third distinguishes between lot delivery equipment and continuous flow equipment. A simple method of classifying equipment is illustrated in Figure 6.

Analysis of the problem. The solution of any given problem of material handling requires, first, the analysis of the nature of the situation in order to determine the possible alternatives; and second, the choice of the most economically desirable alternative. Among the factors to be considered in analyzing the problem are:

1. Nature of the materials.
2. Quantity of material.
3. Distances involved.
4. Direction and variability of movement.
5. Environment in which movement takes place.
6. Protection of quality.

Nature of the materials. The physical properties of materials vary widely. Materials may be handled either in bulk or in packages. These differences affect the choice of equipment. Oil from large storage tanks in an oil refinery may be moved by means of pipes, using pump and gravity to transport it to a tank car; it may be moved by conveyor in large drums to waiting freight cars; or, packaged in one quart cans in cartons, it may be loaded on pallets and moved by electric truck. Similarly, bulk grain may be removed from box car to storage bin through grain hoses by suction or blowing. The processed grain is boxed on a packing and weighing machine with a built-in process conveyor, packed into cartons, and moved to the shipping department by conveyor.

The weight and size of the material lifted and moved also affect the choice of equipment. A locomotive may be moved by overhead crane, watches may be moved by trays, and clothing and furs by truck.

Quantity of material handled. The quantity of material affects the choice of equipment for both packaged and bulk goods. To move a single box from receiving to inspection by a hand truck may be appropriate. On the other hand, if such boxes arrived daily in large numbers a conveyor or electric truck may be called for. In firing one boiler, wheel barrows and shovels may suffice to transport the coal; large boiler installations may justify conveyors and automatic stokers. In short, quantity permits mechanization.

Distances moved. Distance involves travel time as well as cost. Movement by hand truck may be justified where distances are short, but it is costly where distances are long. Frequently overhead conveyors may be used in large plants to tie distant points together. For instance, automobile fenders, hung on chain conveyors, may travel great distances before arriving at the point of use on the assembly line.

Direction and variability of movement. The direction of travel may be horizontal, vertical, or a combination of the two. If it is horizontal and between two points on the same plane, belt conveyors may be used. If vertical and involving a lifting action to load a truck or to stack piles, the lifting operation may be done manually, or by special lifting devices such as tiering machines or lift trucks. Vertical movement between floors may be accomplished by elevators or by gravity. Overhead cranes, lift trucks, and conveyors provide movement of both types. In transporting bags of sugar from an upper floor to a freight car, the same conveyor may be used for the vertical movement and the horizontal movement to the freight car.

Variability of movement in the areas served and the paths followed differs in degree. In machine shops work may need to be moved from one machine to any other. This situation calls for equipment such as cranes and trucks that provide flexibility within the area. Trucks are more flexible than cranes for horizontal movement because they may move from area to area whereas a crane is limited to the area under the craneway. The crane, however, is more flexible for vertical movements. Mass-production or continuous-flow industries, in contrast to machine shops, move large quantities over paths that are fixed, and such situations are ideal for conveyors.

Environment in which movement takes place. The type of material handling equipment that can be used is limited by the physical environment in which it operates. For example, narrow aisles are not adapted to the operation of trucks and trailers. The angle of incline of ramps, the number of floors and their live carrying loads, and the ceiling heights, illustrate other restrictions imposed by environment.

Protection of quality. If the risk of damage to the product is high, as with false teeth, porcelain, and ball bearings, the handling method must protect the product.

The choice of the most economical alternative. The final decision as to the purchase of handling equipment should be based on economy studies. One of the difficulties involved in determining the costs of material handling is the lack, in most companies, of cost records that reflect such costs completely. Frequently handling is performed by direct workers and its expense is hidden in direct labor costs; even when performed by indirect workers, the cost may not be segregated.

Some principles of material handling. Satisfactory solutions of material handling problems ordinarily require adherence to certain principles:

1. Reduce handling and movement to a minimum. For example, the number of handlings is reduced by the use of lift

trucks and pallets, and the distances traveled are reduced by improved layout.

2. Unit loads should be as large as practical. A unit load is the quantity moved or handled at one time. One way of increasing unit load is to attach a series of individual trailers to a tractor that hauls the entire train.

3. Minimize manual lifting and moving to reduce handling, to permit greater unit loads, and to increase the speed of movement of material.

4. Move work at the level at which operations are performed, thus minimizing fatigue and production time. The conveyor at working level is an excellent application of this principle.

5. Material-handling devices and methods should be integrated throughout the plant and tied in with layout and production control.

Questions:

1. Contrast the problem of preparing a layout for a new building with the revamping of an existing layout.

2. What advantage does the scale model have over the traditional templets?

3. May "short moves" be too short for maximum efficiency?

4. Which of the layout objectives have been influenced by improved methods of material handling?

CHAPTER 6

Power and Physical Environment

MODERN industry depends on power. Without it machines would be useless, and factories and offices could not be equipped with modern lighting, air conditioning, and conveying. Recent industrial expansion in the United States is reflected in the increased production of electrical energy, which was 81 per cent higher in the immediate post-war years than in the pre-war period. As Henry Ford has pointed out, this is not a machine age, but an age of power, the use of which is an outstanding feature of our modern life.

Science has so increased the generation of power that, on the average, every man, woman, and child in this country is said to have the equivalent of sixty slaves to help him. In addition, every office in this part of the world requires light and heat, and manufacturing plants often need process steam or process heat. In fact the problems of supplying power, light, heat, and process steam are so interrelated that it is essential to consider them together. If electric power is used, its source of supply is the same as that of the electric light; if steam power is used, it will probably come from the same boiler as the heat or process steam.

To help it solve the technical problems of installing and operating a power plant, management should consult qualified engineers. Just as a business man needs to know enough law to determine when expert counsel is required, so he needs to know enough about his power costs and problems to realize how far he may rely on his own plant engineers and to recognize situations when outside help is advisable.

Among the major decisions an executive must make with respect to the control of power and heat costs are the following: whether to purchase electrical energy from a public utility or to make it in his own power plant; whether to use individual or group motor drive in the operation of his equipment; how to minimize the influence of both load and power factor on power costs; and what methods should be used in the day-to-day control of power costs.

Buy or make power. An outstanding power trend of recent years is for electrical energy to be purchased from a public utility rather than to be produced by the user's own private or isolated power plant. This has resulted from the increased efficiency of large power plants. In those public utilities operated by steam, the trend is toward large units running at high pressures. Electricity can, however, be produced at lower cost by the private power plant when it is generated as a by-product of heating and process steam.

Even the small factory that uses all of its exhaust steam for heating and processing and has a power plant that generates only 100 kilowatts may generate a kilowatt-hour for one-half pound of coal above the quantity needed for heating alone. In addition, exhaust steam can be delivered at high pressures from power units served by high-pressure boilers. Ordinarily, when the ratio of steam per hour to kilowatts is high, as in the manufacture of paper, rayon, plastics, and rubber, and in dyeing and bleaching, the private plant will prove the more economical.

It may be advisable, however, to divide the electric load between the private plant and the public utility. This practice is particularly advantageous when demands for power are irregular, when exhaust steam can be used in the heating months only, and when existing power units are adequate for heating and process work but insufficient for by-product electrical energy.

The decision whether or not to buy electrical power from a public utility depends largely upon relative costs and should therefore be based upon an economy study. In deciding to use a private power plant, however, consideration must be given to certain intangibles. For instance, a rapidly growing business may find not only that the size of its steam generating and power units is inadequate, but that it needs different power-generating equipment. Limited capital may make it advisable to divert to direct operations money that would be used to purchase power house equipment. It is obvious, too, that the executives of a company must assume additional managerial duties if they decide to operate their own power plant.

Controlling the cost of purchased power. If it has been decided to purchase power, the executive is immediately confronted with a series of corollary problems. He must see to it that the public utility offers his company the most advantageous schedule of rates among the available alternatives. He must recognize the cost of heating as an additional item in his total power and heat bill. He must take active steps to correct poor load factor and power factor. If direct current is needed for processing or operating plant equipment, thus making it necessary to convert the alternating current supplied by the utility, he must make sure to use the most economical conversion unit, such as the arc-type rectifier. Even though several feeder lines from the utility are installed, he should insist that all meter readings be totaled and computed as a single bill so that his company may take advantage of lower rates. These are but a few of the opportunities that permit the alert executive to reduce the costs of purchased power.

Almost all public utility power rates are based on maximum demand and monthly consumption. The maximum demand charges are designed to cover the utility's investment costs; monthly consumption covers the cost of generating and transmitting the electrical energy consumed. This energy charge is set up in blocks or brackets, the rates for which diminish as consumption increases. The maximum demand is usually expressed in kilowatts (**kw**); the energy consumed in kilowatt-hours (**kwh**). Sometimes, however, both demand and energy charges are based on kilo-volt amperes (**kva**). Both poor load factor and low power factor require the central station to put into service excessive generating and transmitting capacity. For this reason its rate schedule is fashioned to result in higher charges when either load or power factor is low. A needlessly high demand charge results in higher total costs per kilowatt hour. A low power factor is ordinarily penalized by increasing the demand charge. The utility may base its charge on a norm, such as 80 per cent power factor. The charge is increased when the power factor is below 80 per cent, and decreased when above that norm. When the energy consumed is based on kilo-volt amperes rather than kilowatts, the adjustments are direct.

Control of power-house costs. If the company makes its own power, the executive must deal with a variety of problems that include the selection of power generating equipment and of fuel, and their proper utilization. The chief devices for producing power are steam engines, internal combustion engines, water wheels, and turbines. These may be utilized either to run the machinery directly, or to generate electricity for operating electric motors. Internal combustion engines, such as the Diesel engine or gasoline motor, provide mechanical power or electricity if hooked up with generating equipment. If steam is used, it is necessary to provide a full complement of steam-producing or boiler-room equipment. The steam plants may use either turbines or steam engines; the latter are common in small plants employing less than 250 horsepower. These steam plants may be either condensing or non-condensing, the former being found in large installations. The fuels used may be bituminous coal, anthracite, fuel oil, gas (natural or manufactured), gasoline, or combustible waste from the manufacturing process.

In steam plants the efficient operation of the boiler equipment permits savings in the power and coal bills. The consumption of fuel is a chemical process, which can only be regulated properly with due regard to chemical laws. Through ignorance of these laws, many manufacturers spend more money in heating up the atmosphere than in raising steam. In a coal-burning boiler installation, heat units (the British

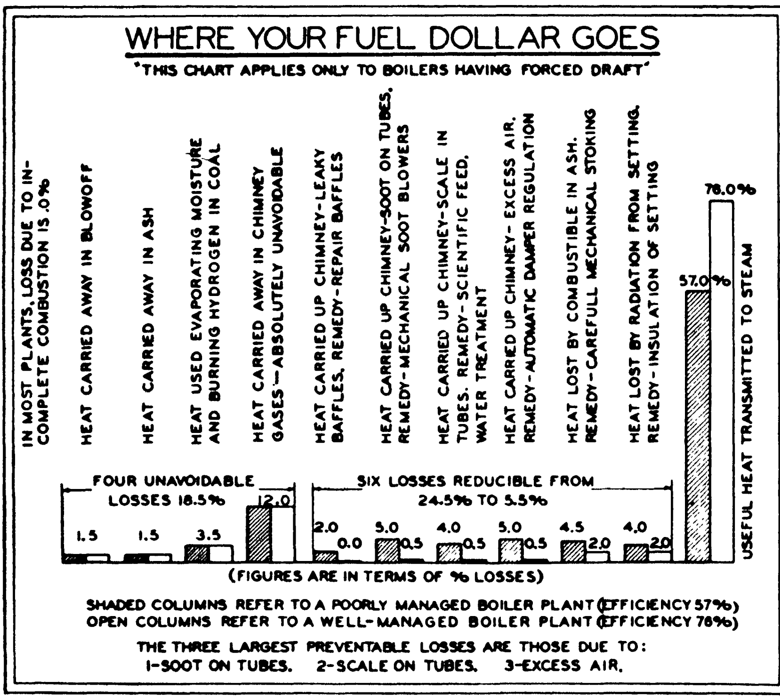


Figure 7.

thermal unit-b.t.u.) may be wasted if chimney temperatures are too high, uncombusted carbon is carried away in ash, the boiler room itself is needlessly heated, or excessive heat is used to evaporate the water. In Figure 7 heat losses and corrective steps are presented in greater detail. Analysis of a specific situation by making a boiler heat-balance is a basic approach in the determination of potential savings in boiler-room operation.

Group versus individual motor drive. In old-fashioned plants the machinery was driven from a single steam engine connected by a belt to a main drive-shaft. The widening use of electricity has brought about a rapid increase in the use of electric motors. These motors are of both the alternating-current and the direct-current types. Those of the alternating-current type are best adapted to constant speeds, but late developments have produced variable-speed, high-torque, A.C. motors. The type of current now most often found is three-phase alternating current, 60-cycle, with a voltage of 110 or 220; for factory power use, 440 volts is standard.[1] Some of the early applications of electricity merely substituted a single motor for the steam engine, but kept the same type of drive, which, because of the resulting maze of belting, shafting, and hangers, gave an impression of dense woods and was exceedingly dirty and covered by cobwebs.

In modern plants, two types of drive are used: group and individual. In group drive one motor drives a group of machines. In most instances two or more motors will be used to drive several groups of machines, and therefore this type is not to be confused with the old-fashioned method of operating *all* machines from a single source of power. Group drive is very common. Since all the machines will not ordinarily be under full load at any one time, the motors need be only large enough to carry the average load. With group drive, however, the losses during the transmission of power are apt to be acute. Some of the common causes of transmission losses are shown in Figure 8.

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[1] Either direct or alternating current will furnish light, heat, and power. Direct current flows in one direction only, in contrast to alternating current, which reverses its direction of flow periodically and rapidly. Direct current is needed for equipment whose speed varies greatly, as for cranes and for such processes as electro-plating. To convert the voltage of direct current to a higher or lower voltage necessitates a motor-generator set that is much more expensive than the transformer performing the same function in the case of alternating current. Consequently, the ease of making voltage changes and the resultant economies in distributing current have made alternating current popular.

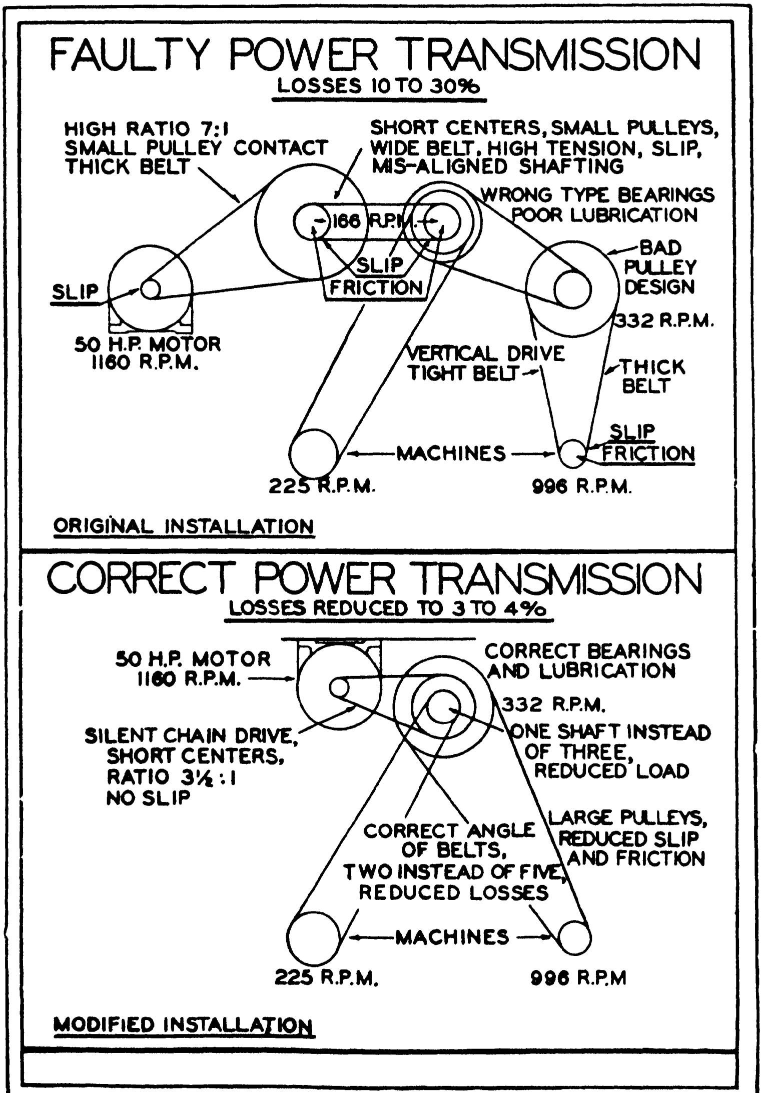
FAULTY POWER TRANSMISSION
LOSSES 10 TO 30%
HIGH RATIO 7:1
SMALL PULLEY CONTACT
THICK BELT
SHORT CENTERS, SMALL PULLEYS,
WIDE BELT, HIGH TENSION, SLIP,
MIS-ALIGNED SHAFTING
WRONG TYPE BEARINGS
POOR LUBRICATION
166 R.P.M.
SLIP
FRICTION
SLIP
BAD PULLEY DESIGN
332 R.P.M.
50 H.P. MOTOR
1160 R.P.M.
VERTICAL DRIVE
TIGHT BELT
THICK BELT
SLIP
FRICTION
MACHINES
225 R.P.M.
996 R.P.M.
ORIGINAL INSTALLATION
CORRECT POWER TRANSMISSION
LOSSES REDUCED TO 3 TO 4%
50 H.P. MOTOR
1160 R.P.M.
CORRECT BEARINGS
AND LUBRICATION
332 R.P.M.
SILENT CHAIN DRIVE,
SHORT CENTERS,
RATIO 3½:1
NO SLIP
ONE SHAFT INSTEAD
OF THREE,
REDUCED LOAD
LARGE PULLEYS,
REDUCED SLIP
AND FRICTION
CORRECT ANGLE
OF BELTS,
TWO INSTEAD OF FIVE,
REDUCED LOSSES
MACHINES
225 R.P.M.
996 R.P.M
MODIFIED INSTALLATION

Figure 8.

Individual motor drive provides an individual motor for each machine. Although its initial cost is higher, it permits the relocation of machines without regard to shafting and the running of the machine at any speed desired. The use of fractional horse-power motors is increasing. These are small motors, sometimes of less than one horse-power, applied directly to the point of use.

Individual drive is applicable in the following situations:

1. Where head shafts and belts would interfere with the operation of cranes.

2. Where the units of product worked upon are so large that it is cheaper to move the machines to them.

3. Where machines, such as printing presses and machine tools, are large and operate uniformly at approximately full load.

4. Where special applications require such frequent stops and starts as to employ a large part of a tender's time and make electrical control more convenient than mechanical control through clutches and brakes.

5. Where the majority of machines run for part of the year only, but the remainder run continually, as in highly seasonal industries.

The disadvantages of individual motor drive are of at least two kinds:

1. The initial cost is higher. The capacity of the motor installed on a machine with individual drive must be adequate for the heaviest job that the machine can do. The motors in such a department often need four or five times as much horse power as when group drive is used. Moreover the cost per horse power of small motors is greater than that for large ones.

2. The average load on an individual drive motor may be only a part of its capacity, often only a third. With the usual commercial motor the results are poor power factor and a higher price for current.

Because the machines used in most plants vary in their power requirements, the decision as to whether to use group drive or individual drive should not be made for the plant as a whole, but should be made separately for each class of machine. Not only is there an ideal field for each, but in many situations either may be used satisfactorily. Consequently most plants employ both types.

Improvements of load factor and power factor. *Load factor,* for the user of electricity, is defined as the ratio of actual power used to peak power used.[2] The peak load is indicated by a maximum-demand meter and is usually measured over a fifteen minute period. Thus if a company has a peak load of 1000 **kw** and uses 350,000 **kwh** of electricity during a month in which it operates 700 hours, its load factor will be 350,000 ÷ 700,000 or 50 per cent. It is apparent that, whether electricity be purchased or produced, sufficient equipment must be kept ready to supply the peak load. Low load factor leads to surplus equipment, and therefore increases the cost of electricity.

Executive action may improve the plant's load factor by decreasing maximum demand. The operation of processes that require high electrical loads may be staggered so that they do not pyramid the demand; or the simultaneous starting of heavy machines may be avoided by proper scheduling; or group drive, where technically suitable, may reduce the total installed load.

Power factor may be defined as the ratio of kilowatts (actual power used) to kilo-volt amperes (apparent power put into the line by the generator). Power factor is the result, not of leaks or friction, but of idle energy, or wattless power, caused by induction in the line when alternating current is used; it never occurs with direct current, nor is it related to the operating efficiency of the motor. Low power factor makes it necessary to have larger generators, lines, and transformers, since each kilo-volt ampere of generator capacity will yield something less than a kilowatt of power. If, for instance, the com-

[2] This is a more narrow use of the load factor concept than that discussed previously.

pany's demand, as indicated on its meter, is for 1500 **kw** of electricity and its power factor, as measured by a power-factor meter, is 75 per cent, it will be necessary to provide generator capacity of 2000 **kva**. The relation of this extra investment to the cost of power needs no elaboration.

As in the case of load factor, the objective of every manager responsible for power costs should be to get and keep his power factor as near unity as possible. Since the use of induction motors at less than their rated capacities is a cause of low power factor, a manager should see that the induction motors selected are of proper size for the load. In addition, he may employ special corrective devices, such as capacitors and synchronous motors. If fluorescent lights are used, he should make sure that they contain power-factor correction devices.

Methods for the routine control of power costs. In the day-to-day control of power costs the attention of the manager should be directed along two lines: (1) the use of operating practices and devices that will reduce the wastage of steam, compressed air, and other things which power is used to make; and (2) the adoption of control methods that use measuring instruments, and standards or "yardsticks" to determine operating efficiency. Records and reports based on these permit the correction of improper operation of the power-producing equipment.

Typical of the former are the insertion of a small disc with a hole in it in the air line to reduce the air pressure available for oil burners and the installation of automatic cut-offs on air compressors to permit the motor to run idle whenever the pressure exceeds a given amount.

Illustrative of the latter are meters that record steam and air flow, flue-gas temperature, and furnace draft. When the cost of power warrants their use, these may yield substantial savings in the operation of boilers. The consumption of electricity and characteristics of load can be measured for various parts of the plant or even for individual machines, like a large power press, and significant operating and power economies secured by appropriate improvements.

The metered performance of boiler and motor equipment can be interpreted best if used with standards or "yardsticks" that represent good practice. Such standards can be developed for fuel, flue, water and steam temperatures, ash content, and draft, as well as for the amount of steam that should be secured per ton of coal or for the electric current needed for a given amount of product.

Backed by standard practice instructions for the proper operation of power-generating equipment, comparison of standard and actual performance assists in securing efficient operation. Records and reports show the manager how actual power costs compare with standard. Among the useful data for a manager to watch are:

1. The average unit cost of power production in cents per kilo-watt-hour. This is a rough check on the power engineer but conveniently summarizes all cost elements.

2. The ratio of pounds of coal burned to pounds of feed water. This is a measure of boiler-room efficiency.

3. The ratio of pounds of coal burned to kilowatt-hours of energy produced to measure the efficiency of the entire power plant.

4. The ratio of pounds of steam to units of product. This provides a measure of the efficiency with which power and steam are utilized by the factory.

In addition, major elements of power cost, such as labor and coal, may be segregated for special study. The precise methods of control must be tailored to the needs of a given situation.

Problems in Computing the Cost of Power

1. A certain cement plant, operating 25 days a month with an output of 2,000 barrels of cement every 24 hours, has installed 2,000 horsepower in motors. Its average demand over a 24-hour day is 1,400 kilowatts, and its maximum demand measured over a period of 15 minutes is 1,700 kilowatts. Power is supplied by the central station at a rate of 1¢

per kilowatt-hour, plus $1.00 per month per kilowatt of maximum demand, based on an average power factor of 85 per cent. It is common practice among power companies to employ a "demand and energy" rate, which is a flat service charge combined with a fluctuating charge depending upon the actual amount of electrical energy used. The energy rates are usually on a sliding scale so that they decrease per unit as the quantity consumed increases. The flat demand charge is based on the customer's maximum average demand over a given period of time, and on his agreement to use a minimum amount of current during each month.

In this case, for a power factor below 85 per cent, the demand charge is increased in inverse ratio of the power factors, and for power factors above 85 per cent, a rebate is allowed on the same basis up to a power factor of 100 per cent.

a. On the basis of 85 per cent power factor, what is the total power bill per month and the cost of energy per barrel of cement?

b. If slow speed induction motors are used for most of the drives, so that the power factor falls to 75 per cent, what will be the added energy charge per barrel of cement?

Physical Environment

The physical environment in which employees work influences their morale, safety, and performance. The principal environmental factors affecting them are lighting, color, condition of air, and noise.

Lighting. The manager is interested in factory lighting primarily because of its effect upon the cost of production. Poor illumination causes spoilage and poor quality of product, eyestrain and fatigue, and accidents. Improved illumination alone, other conditions remaining constant, has increased output markedly. The results of certain experiments are shown in the following tabulation.

The principal qualities of good lighting are adequate intensity, proper diffusion, and absence of glare.

Intensity. By intensity is meant the amount of light supplied to the working plane of the machine or work place. The unit of illumination intensity is the foot-candle and intensity can be measured by a small portable instrument called a foot-candle meter. The required intensity varies, depending

TABLE 1.

SUMMARY OF PRODUCTION TESTS[1]

Kind of Work	Increase in Intensity in Footcandles	Increase in Production in Per cent	Cost of Increase in Per cent of Pay Roll
Stamping and Pressing....	12.3	12.2	2.5
Semi-automatic Buffing...	7.6	8.5	1.9
Iron-Pulley Finishing.....	4.6	35.0	5.5
Soft Metal Bearings.......	8.1	15.0	—
Heavy Steel Machining....	8.7	10.0	1.2
Carburetor Assembling....	10.4	12.0	0.9
Spinning (Textile Mill)....	7.5	17.0	—

[1] Industrial Lighting, Lighting Service Department, Edison Lamp Works of the General Electric Company, Harrison, N. J.

upon the nature of the work; for example, rough manufacturing requires a lower intensity than fine inspecting. The intensity recommended by lighting authorities for various types of work has been increased constantly. At one time, even for the closest work, no intensities higher than fifteen to eighteen foot-candles were used; at present, over two hundred foot-candles are recommended for certain work.[2]

> 200 foot-candles or more—for very severe and prolonged tasks such as cutting, inspecting and sewing dark goods, engraving, jewelry and watch manufacturing, or extra-fine bench and machine work in machine shops.
>
> 100 foot-candles—for severe and critical tasks, such as fine assembly work, coil winding, etching and decorating glassware, fine inspection, or grading cotton textiles.
>
> 50 foot-candles—for critical and prolonged close work, such as drafting and designing in detail, fine hand-painting and finishing, or hand-pressing clothing.
>
> 20 to 40 foot-candles—for moderately critical and prolonged tasks, such as clerical work, ordinary reading, common bench work and similar jobs.

[2] IES Lighting Handbook. New York: Illuminating Engineering Society, 1947.

10 to 20 foot-candles—for visually controlled work, such as cleaning castings, packing and boxing, or forging metal, where seeing is important, though more or less interrupted and casual, and where discrimination of fine details, or of low contrasts, is not involved.

Diffusion. By proper diffusion is meant an even spread of light over the working plane, with freedom from sharp contrasts between light and shadow. It is an essential of good lighting to eliminate eyestrain caused by constant adjustment to varying intensities of light. Proper diffusion depends largely upon the distribution of light sources and upon the kind of reflector used. Improper diffusion is one of the principal causes of glare, which has been defined as "light out of place." Still other causes of glare are too great intensity, improperly reflected light, too sharp a contrast with the background, and improper location of the source of light.

In recent years increased attention has been given to brightness contrast as a factor in good vision. As indicated above, levels of illumination, expressed in foot-candles, represent light received by a surface. However, what the eye actually sees is the reflected light, or brightness. Brightness is measured in foot-lamberts, which equal the foot-candles received multiplied by the reflection factor. The reflection factor of a surface depends upon its nature and color. Hard, polished surfaces reflect more light than do soft, dull ones. The reflecting properties of colors range from 82 to 89 per cent for white to a very low percentage for black. The difference in reflecting properties of black and white provides a sharp brightness contrast that makes seeing easy when these colors are used together. Reading is made easy by black print on white paper, sewing by black thread on white cloth, and driving is safer when bridge abutments are painted in alternating black and white. On the other hand, seeing is difficult where brightness contrast is low. Sewing on black cloth with black thread is difficult not only because of the low reflection factor of the color, but also because of the absence of brightness contrast. For such work the level of illumination must be high.

Color of light. For ordinary factory and office work, the color of the light should approximate daylight, because it is easy on the eyes and colors may be discriminated accurately. Mercury vapor light is deficient in red rays, and it is used for detecting imperfections and for extremely detailed work like that in composing rooms. Fluorescent lighting has come to be accepted widely. It may be obtained in a variety of colors. For factory work the most popular ones are white and daylight; the white light gives a warm effect, and the daylight permits accurate color discrimination.

Color of paint. Recognition of the importance of brightness contrast has changed the painting of industrial interiors and equipment. DuPont and the Philadelphia Electric Company collaborated in developing "three-dimensional seeing," which employs combinations of colors and lighting that give proper brightness contrast and illumination.

The reflecting properties of various colors are as follows: [3]

Color	*Per Cent of Light Reflected*
White, New	82-89
Ivory	73-78
Cream	62-80
Yellow	61-75
Buff	49-66
Light Green	48-75
Light Blue	34-61
Dark Tan	30-46
Grey	17-63
Dark Red	13-30
Dark Green	11-25
Light Wood Varnish	42-49
Natural Wood, Brown Stain	17-29

[3] Adapted from Lighting Data Bulletin of Edison Lamp Works, General Electric Company.

The varying properties of different colors have been used in the physical environment to obtain benefits other than good visibility. Blues and greens are "cool"; yellows and reds are "warm"; pastel shades are "restful"; and bright yellows, reds, and oranges are "attention-arresting." Plans have been developed for the comprehensive use of color in industry to take advantage of these effects, not only for better vision, but for improved employee safety, comfort, and morale. DuPont calls its plan "Color Conditioning" and Pittsburgh Plate Glass Company calls its, "Color Dynamics."

Types of lighting. Lighting may be natural or artificial. Natural lighting usually relies upon windows and skylights, but even the walls may be constructed of glass brick. Roofs of saw-tooth construction provide maximum lighting from above, and ribbed glass windows provide maximum deflection of light rays into the building. However, few firms rely solely upon natural light, because of sun glare and varying intensities, and supplement it by, or even replace it with, artificial lighting.

Three distinct methods of artificial lighting are in use: general lighting, localized general lighting, and supplementary lighting. General lighting provides a relatively uniform level of illumination throughout the entire area; with localized general lighting, light sources are located with reference to the illumination of a group of machines or workplaces; supplementary lighting provides additional illumination at critical points from local light units, and is used to secure very high intensities without making the general lighting too bright and costly.

The operating effectiveness of any lighting system depends upon adequate maintenance. Dirty windows, walls, lamps, and reflectors, and worn-out lamps greatly reduce the efficiency of the system. Merely cleaning lamps and reflectors has added 20 per cent to the light obtained.

Air conditioning. Much attention has been directed to the importance of providing proper air conditions, because of their effect upon the efficiency of the workers, and/or upon the behavior of materials and machines. Since the needs of materials and workers are not always identical, there may be a conflict between the conditions that are ideal for each. The efficiency of the worker is affected by his inability to produce at his best when the air in which he is working is too cold or too warm, too dry or too moist, when it is stagnant, or when it contains dust or poisonous gases. Poor air conditions lessen the efficiency of workers not only by producing a feeling of lassitude, but also by affecting their general health adversely. It has been found, for example, that absences caused by colds can be greatly reduced.

Because of the nature of the materials and machinery used, many industries must control air conditions if the proper quality and quantity of production are to be obtained. For example, certain types of textile mills must control humidity carefully: if the air is too dry, the yarn will break, but if it is too moist, the yarn will absorb moisture and create an uneven product. Bakeries and meat-packing and rayon plants are among those that must control both the temperature and the humidity if a standard product is to be obtained. In hosiery and other industries using delicate or finely adjusted machinery, the undue expansion and contraction of the machines from changes in temperature, as well as the formation of rust and static electricity from improper humidity must be prevented.

In complete air conditioning, temperature, humidity, motion, and quality of air are simultaneously controlled. Temperature control involves heating or cooling air in order to reach certain desired levels; humidity control involves adding or subtracting moisture. Comfort and maximum efficiency are obtained when the relative humidity and temperature are in proper relation to each other and to outside climatic conditions. For example, at a high relative humidity of 80 per cent, one may be comfortable at 58 degrees of temperature; and at a low relative humidity of 10 per cent, at 77 degrees. The usual comfort zone for clerical employees is achieved with a relative humidity of 40 to 50 per cent, and a temperature of 67 to 70 degrees Fahrenheit. However, if the outside temperature is very high, say 95 degrees or more, higher temperatures should be maintained inside.

Good ventilation requires the maintenance of "fresh" air and proper circulation. The introduction of outside air complicates problems of temperature and humidity control, but is necessary for proper quality. In the circulation of air, excessive movement or drafts should be avoided. Facilities for removing dust, fumes, smoke, gases, or odors may also be required. In some industries, for example, where the product absorbs odors from the air, it is necessary to pass the air through filters containing activated carbon in order to eliminate them.

Noise control. The efficiency of employees is affected by the intensity and kinds of sounds. The level of sound may vary from the threshold of human hearing to sound so intense as to be painful. Its intensity is measured in "decibels" by devices similar to radio's "applause-meter." The greater the intensity of noise in the working environment, the more fatigue is induced. Sounds may be pleasant or unpleasant, musical or discordant. Distracting noises may interrupt production. High-pitched, intermittent, and irregular sounds are particularly distracting. On the other hand, music in the workroom may provide a pleasant break in monotony, soothe jangled nerves, or perk up sagging spirits. Properly applied, its use may improve morale and increase output.

Noise control seeks to reduce intense or unpleasant noise, whether it originates inside or outside the factory. One approach is to eliminate noise at its source. Rubber tires on milk wagons reduce the noise levels of city streets as did the "noiseless" typewriter in the office. Punch presses and drop hammers may be so mounted as to muffle the sound of the operation. Another method is to reduce the transmittal of the sound waves by absorbing them. Hard or polished surfaces reflect sound, but soft or porous materials absorb it. Therefore noise is reduced by drapes, rugs, and sound-absorbing ceilings. If it is impossible to eliminate noise at its source or to reduce its intensity by absorption, it may be necessary to isolate noisy operations.

Questions:

1. From the discussion of individual drive, outline the advantages and disadvantages of group drive.

2. A cereal manufacturing company operating 176 hours per month buys 83,400 kilowatt-hours of electricity. Its measured maximum demand is 560 kilowatts and its power factor 80 per cent. It has installed a capacitor to raise its power factor to unity. The applicable schedule of power rates is:

First power block of kilowatt hours equal to 70 times the kva demand—	rate $0.0550
Second power block of kilowatt hours equal to 70 times the kva demand—	rate 0.0125
Third power block of kilowatt hours equal to 70 times the kva demand—	rate 0.0100
All in excess of above	rate 0.0075

(a) Compute the monthly power bill and the cost per kilowatt-hour for this company before and after installation of the capacitor.

(b) Compute the load factor for the company.

3. What is the relationship between glare and illumination intensity?

4. Appraise the natural and artificial illumination in your classroom.

5. Illustrate the use of air conditioning to improve worker efficiency, to reduce health hazards, and to facilitate processing.

CHAPTER 7

Maintenance of Plant and Equipment

In highly mechanized plants, machine failure has far-reaching effects. In an automobile assembly plant, it may result in the waste of time of hundreds of workers or may conceivably close down the entire plant. Production activities are so interrelated that it is futile to permit the plant to operate if one of its departments is shut down. The breakdown of a key machine in almost any mill or office is troublesome. Moreover, as mechanization increases, the ratio of property investment to total assets likewise increases. The return on this investment depends, among other things, upon continuous operation of the equipment and upon proper maintenance.

Moreover, quality suffers when machines are so worn and poorly maintained that tolerances cannot be held except at excessive cost. It is futile to install improved lighting and air conditioning, and to paint the walls and equipment, which is necessary to efficient operation for the reasons already indicated, unless these new standards are maintained.

Performance standards are based upon certain established conditions, and failure by the management to maintain these conditions may prevent the worker from turning out the expected production. The fact that these causes of inefficiency are beyond the worker's control breeds employee irritation. It is unfair to ask employees to do a job in a given time when, because of poor maintenance, the machine operates more slowly than anticipated.

Scope of maintenance activities. Maintenance activities fall into three classes: routine maintenance, repair work, and preventive maintenance.

In every plant there is a certain amount of maintenance work that is routine. Lubrication, cleaning, collection of waste, replacement of bulbs, and the charging of batteries on electric trucks are typical examples. Of these, lubrication is particularly important because a large percentage of breakdowns is attributable to improper lubrication. Proper lubrication requires that the right oil is supplied sufficiently at the points where it is needed. In recognition of its importance, the responsibility for lubrication has frequently been removed from the machine operators and assigned to oilers. A still further development is to design machines so as to make their lubrication automatic. In addition to routine maintenance, many maintenance departments have other routine responsibilities such as the operation of the boiler house, fire and police protection, janitorial service, non-routine moving, and construction work.

Repair work. Repairs are needed in every business. Some of these repairs are minor in nature, but are so numerous as to provide a backlog of work. A second category consists of emergency repairs, which are needed unpredictably and which interrupt production. Still another group of repairs results from the attempt to anticipate breakdown by regular inspection and overhaul. There are always breakdowns of machinery and equipment requiring immediate attention.

Preventive maintenance. The basic idea behind preventive maintenance is the use of periodic inspection to detect wear and tear in advance of breakdown. This permits the planning of repair work in advance when it will interfere least with production. Such planning may also reduce the cost of the repair work itself. A system of preventive maintenance requires certain fundamentals: [1]

1. The frequency of inspection, as illustrated in Figure 9, must be determined from the repair record of each type of

[1] In many plants, the maintenance department also installs new machines and the foundations, piping, and wiring incident thereto, makes alterations to plant property, and moves machines when layouts are modified or locations changed. Strictly speaking, these are not maintenance activities.

equipment. After the frequency of inspection has been determined, a schedule can be prepared to insure inspection at proper intervals. A tickler file can then be used to indicate the items to be inspected on a particular day.

2. Responsibility for inspection must be placed upon properly trained inspectors, preferably full-time, for when inspection is added to the regular duties of such maintenance men as millwrights and electricians, it is likely to be neglected.

3. Should a machine or a piece of equipment break down in spite of regular inspections, a careful investigation should be made to determine why the breakdown was not prevented.

Item	Period of Inspection
Elevator Gates....	Daily
Elevator Cables.	Daily
Conveyors.	Daily
Scales.	Weekly
Tanks and Containers.	Weekly
Fire Protection System.	Weekly
Shafting and Hangers.	Monthly
Plumbing Fixtures and Fitting.	Monthly
Hydraulic Pumps.	Monthly
Sprinkler Lines and Valves	Monthly
High-Pressure Steam Lines.	Monthly
Electric Lamps.	Semi-annually
All Pressure Gages.	Semi-annually
Floors Inspected and Repaired.	Semi-annually
Turbine (Steam).	Annually

Figure 9. Inspection Timetable for Maintenance of Equipment

Maintenance and replacement policies. The basic policies that management must settle are as follows:

1. To time deferrable maintenance projects, so that they will be carried out either in slack times when costs are low and the workers need employment or in more prosperous times when cash does not need to be conserved.

2. To have repair work done by the company's own labor force or to "let it out" on contract.

3. To establish a separate maintenance department or to assign the responsibility to operating executives.

4. To replace machines according to a definite program or to replace them on a haphazard basis. Salesmen's autos, trucks, and typewriters are frequently "traded in," regardless of condition, after a given number of years. Others replace them on an individual basis when maintenance costs become excessive or the machines become unusable. A definite program is desirable if a company wishes to keep its equipment up-to-date in order to insure that it will be able to compete.

One company replaces each machine every seven years. Because of effective maintenance, this company has been able to resell its equipment at prices averaging 46 per cent of original cost. Another lists as obsolete all equipment that has been in the place over 10 years, and retains an over-age machine only if the Works Manager convinces his colleagues that its retention is desirable. Still other companies appropriate funds for new equipment in a definite annual amount and rely upon economy studies to indicate which pieces of equipment shall be replaced during that year.

Control. In the control of maintenance the following devices are used:

1. Authorization of work.
2. Scheduling of projects.
3. Budgeting and cost data.

All requests should be carefully scrutinized as to the need for the work, the availability of funds, and the priority of the projects. A responsible executive should authorize each expenditure. To relieve top executives of this burden, a common device is to permit foremen to authorize expenditures up to, say, $20.00; the superintendent up to $300.00; and higher executives up to a limit set by the board of directors.

Maintenance work should be so scheduled that it will be performed promptly, with the minimum interruption of production, and the least waste of time between maintenance jobs. Since many of these require workers of several crafts who cannot work simultaneously, their respective tasks should be scheduled so that they will not interfere with each other. If the millwrights arrive to place a machine before the concrete men have poured their concrete, a delay is bound to ensue.

Records are needed to reveal the cost of completed projects, to estimate cost of future projects, and to guide the shaping of maintenance and replacement policies. Control of individual jobs in process can be secured by comparing actual costs with the estimates for them; control of aggregate maintenance expense can be secured by comparing cumulative costs with the budget allowance. Another form of control uses the equipment card—a separate record kept for each piece of machinery and equipment. On it is entered original cost, repair expenditures, and the nature of the repairs. Such a record discloses the frequency, cost, and causes of breakdown and hence aids in making economy studies and replacement decisions.

Organizing and staffing. The department responsible for maintenance of plant and equipment and for certain service activities is frequently called the plant engineering department, and its head is called the plant engineer, works engineer, or maintenance superintendent. This individual generally reports to the executive in charge of production.

Within the plant engineering department, there are usually found three major divisions. These are: (1) electrical maintenance, which embraces the installation and maintenance of electrical equipment, including sub-stations, electric drives, lighting, and signal, alarm, and electrical control systems; (2) mechanical maintenance, which covers the installation and repair of machines, mechanical drives, and lubrication; and (3) building maintenance, which includes the maintenance of buildings and grounds, plant protection, janitorial services and construction.

The first of these is normally directed by an electrical engineer who supervises electricians, and instrument repairmen; the second, by a mechanical engineer, or master mechanic, who supervises machinists, millwrights, riggers, and oilers; and the third, by a building superintendent or boss carpenter, who supervises the carpenters, plumbers, roofers, steamfitters, janitors, gardeners, and watchmen. The crafts required and the number of employees in each one will vary with the relative importance of the foregoing types of work.

In the maintenance department the clear definition of duties and responsibilities is doubly important. Because the activities are numerous, varied, scattered, and interrelated, the work may be either neglected altogether or duplicated. For example, failure to assign motor lubrication definitely to either the lubrication department or the electrical department may mean that motors will not be lubricated at all or that they will be oiled by both groups.

Maintenance is the handmaiden of production. Economy in department operation that impairs service is false economy.

Maintenance Problem

A large company manufacturing screw drivers, files, knives, trowels, shears, squares, and levels, occupies a plant that covers 25 acres of ground. It employs 2,500 workers. The buildings are of mill-type construction, one and two stories high.

About 20 per cent of the power used is generated by the company, and the remainder is purchased from the local electric company. Steam, in addition to being used for heat in the winter time, is required for process purposes, especially in connection with the dry kilns. About 5 per cent of the machines use individual motor drive and the remainder use group drive. Ordinary repairs to belts are made in the various manufacturing departments, rather than in the maintenance department.

The types of machines used are presented below. Only a small percentage of these has been purchased within the last five years.

Planers	Drill presses
Milling machines	Gear cutters
Shapers and slotters	Boring mills
Lathes	Screw machines

Filing machines	Punch presses
Small grinders	Large grinders
Woodworking machines	Heat-treating furnaces
Drop hammers	Buffers and polishers
Shears	

Machine operators are responsible for the lubrication and cleanliness of their own machines, but a special oiler lubricates the main-line shaft bearings. Individual departments specify the oil they desire to use and secure it by requisition from the purchasing department.

The following list of 127 men constitutes the total personnel of the maintenance department. Coordination of the various crafts is not always obtained.

29 Machinists	4 Engineers	9 Carpenters
6 Tool makers	8 Elevator operators	4 Painters
2 Millwrights	20 Firemen	2 Plumbers
7 Blacksmiths	2 Electrical operators	2 Tinsmiths
2 Pattern makers	1 Oiler	2 Riggers
2 Iron workers	7 Laborers	7 Steam fitters
2 Roofers	9 Electricians	

Minor repairs and adjustments to the machines are made by the machine operators. For more important repairs, the foreman makes out a repair order, which he sends to the maintenance department. Work for which the estimated expenditure is less than $200 is performed upon order of the foreman alone, but work that involves larger expenditures requires the approval of the superintendent. About 80 per cent of the total number of orders cost less than $200.

All materials are purchased by the purchasing department on requisition from the maintenance department. Material standards have not been developed. There is no record kept of individual pieces of equipment. Costs are kept by class of equipment and by department, but it has not been the policy of the company to give the foremen cost information.

Maintenance employees are paid day rate.

Within the next two years the company proposes to spend a large sum of money in modernizing its plant and equipment. This program is estimated at least to double the size of the maintenance department. The company realizes that the latter is not being operated effectively. In view of the large sums of money to be spent, it is desired to effect the department's reorganization.

Problem:

What policies and procedures could be applied to reduce maintenance costs in this plant?

Questions:

1. If it is true that the foreman is primarily interested in production, and that poor maintenance of machinery and equipment results in decreased production, why is it not safe to place upon the foreman the responsibility for its maintenance?

2. Would you give to the maintenance department the authority to order the shutting down of a machine until it is repaired?

3. To what extent has the machine operator any responsibility for the condition of the machine and tools entrusted to his care?

4. To what extent do you think it would be profitable to keep individual records of the maintenance of every machine in a machine shop?

5. Discuss the advantages and disadvantages of requiring the machine tender to lubricate his own machine. Are there any conditions under which this practice might be considered sound?

Section III

STANDARDIZATION AND WORK SIMPLIFICATION

CHAPTER 8

Standards and Standardization

UNFORTUNATELY there has been much misunderstanding and confusion as to the interpretation of the terms "standard" and "standardization" as applied in industry. Nor are dictionary definitions entirely satisfactory, from the management viewpoint, in clarifying the meaning of management standards. However, such a definition provides a useful introduction to the subject. In Funk and Wagnall's "New Standard Dictionary," these definitions are given:

> Standard: (1) Any measure of extent, quantity, or value established by law or by general usage and consent; a weight, vessel, instrument, or device sanctioned or used as a definite unit, as of value, dimension, time, or quality, by reference to which other measuring-instruments may be constructed and tested or regulated. (2) Hence, any type, model, example, or authority with which comparison may be made; any fact, thing, or circumstance forming a basis for adjustment and regulation; a criterion of excellence; test; as a standard of portion by weight of fine metal and alloy established by authority.

Characteristics of a standard. The use of standards in industry has been criticized as a bar to progress. This criticism is based on the assumption that, like social standards, all standards yield grudgingly to change and inhibit improvement. However, even scientific standards are modified as knowledge is gained through research. It is only the units used for measuring size, weight, speed, time, energy, and volume that must be kept constant. The confusion that results from changes in units of measurement is illustrated by money. Even though the value of a unit of currency may be expressed as a given weight of a precious metal of specified fineness, history discloses that currency may be devalued from time to time. Or for other reasons the purchasing power of a currency unit may change. When the currency unit varies in value from moment to moment, from place to place, or from person to person, as during disastrous inflationary periods, it ceases to be useful as a standard. It follows therefore that if a standard is to be used as a reference for comparison, it must be constant at a given time, in a given place, and within a given group.

Industrial standards are also subject to change. That they are not constant and do not therefore deter progress is made clear by H. S. Osborne, Chief Engineer, American Telephone and Telegraph Company:

> In many cases the new standards replace existing standards due to advancement in the art, improvements in technique, or changes in operating requirements. Standardization is, therefore, not a static thing, but is dynamic, involving a continuous procession of new standards to meet new conditions or to meet old conditions better than was heretofore possible, and the consequent dropping of the old standards.[1]

A second criticism of industrial standardization has been that it makes for a dull, monotonous "sameness" that stultifies life. This criticism is based on the assumption that standardization is synonymous with uniformity. While it is true that some standards, such as the unit of length, have been adopted by international agreement for universal reference, industrial standards are not uniform. Why standardization requires variety is clearly shown by Frederick W. Taylor's study of material handling. He found that the most economical load for a shovel was twenty-one pounds. Since the weight of a given volume weighing twenty-one pounds varied with the material, a shovel of different size was indicated for each ma-

[1] National Industrial Conference Board, "Industrial Standardization." *Studies in Business Policy*, 1947, No. 22, page 17.

terial handled, coal, ashes, sand, or coke. Standardization, in this sense, stresses functional design rather than uniformity.

Functional standardization does not imply perfection, but rather the adoption of the best method, specification, or condition for a given purpose at the time. If a company were engaged in the manufacture of a line of product for a low-priced market, it would not use the best material obtainable, but one consistent with the price at which the product is sold. The adoption of the best method, part, specification, or condition for a given purpose may conflict, however, with the urge to achieve uniformity for the sake of lowering manufacturing costs. Thus a designer may specify two sizes and types of bolts, "best" for their respective purposes although they differ slightly. If one would serve both purposes, it would normally be used. However, there is a limit beyond which the "best" should not be sacrificed to obtain uniformity. The goal of management is to achieve balance between the quality and operating economy linked with functional adaptation and the reduction of inventories and repair cost that stem from uniformity.

Types of industrial standards. Industrial standards fall into two broad groups: technical and managerial. Standards for the size, shape, composition, and color of a product and its parts are technical in nature. So, too, are those standards that govern processes and equipment. Managerial standards apply to systems, organization practices, procedures, methods, and expected performance.

Standards departments, where found, are normally responsible for technical standards; rarely are they responsible for managerial standards.[2] The organization and coverage of such departments vary from company to company, but generally the activities include: standards for parts, such as bolts and nuts; standards for drafting practice; standard terms and symbols; specifications for materials; standard test proce-

[2] National Industrial Conference Board, "Industrial Standardization." *Studies in Business Policy*, No. 22, page 12.

dures; standards for tools, technical processes, methods and equipment; and standards for fits, finishes, and tolerances. Technical standards are primarily used in purchasing, in designing, and in manufacturing, and to insure their continued use they are often set forth in manuals.

Managerial standards cover operating conditions and performance. Operating standards have been defined by Morris L. Cooke as "A standard under scientific management is simply a carefully thought-out method of performing a function, or carefully drawn specifications covering an implement, or some article of stores or of product." [3] Performance standards for factory and office employees usually take the form of time allowed for performing work. They may also be set up for departments and functions. A budget, for example, may represent the standard with which a department's expense performance is compared; a sales quota, one by which sales performance is judged. Somewhat comparable to purchase specifications based upon technical standards are hiring specifications based on managerial standards. In contrast, instruction sheets, which specify how a worker is to perform a job, illustrate managerial standards that embody technical standards governing the process.

How standards are set. A history of the early experiments in standardization is of chief value if it explains in the simplest terms the principles involved, and shows the major steps necessary to solve management problems by sound research methods. In his book, *The Economy of Manufactures* (1832), Charles Babbage, the English mathematician, has included many references to primitive improvements in machine design and several time studies of English pin making.[4] The auto-

[3] "Academic and Industrial Efficiency." *Bulletin*, Carnegie Foundation for the Advancement of Teaching, No. 5, page 6.

[4] Charles Babbage compares the cost of making pins in England with cost figures deduced from the observations of M. Perronet as to the time and cost to make a batch of 12,000 pins in France about 1760. Charles Babbage, *The Economy of Manufactures*, pages 176-190. London: Charles Knight, 1833. 3rd edition.

biography of Benjamin Franklin suggests a set of experiments dealing with the design and operation of sailing vessels. "A set of experiments might be instituted, first, to determine the most proper form of the hull for swift sailings; next, the best dimensions and properest place for the masts; then the form and quantity of sails, and their position, as the wind may be; and, lastly, the disposition of the lading." [5]

Frederick W. Taylor's interest in determining what the output of a man and of a machine ought to be led him eventually to devote long years of research at Midvale and Bethlehem on the art of cutting metals. Before he could determine how much a workman ought to do, he found that he must be able to tell the man what tool, feed, speed, and depth of cut to use in operating his machine. But even the proper tool was unknown at the beginning of the experiment, and the answer to this question led to the discovery of high-speed tool steel by Taylor and White.

Taylor himself described the importance of standardizing the machines and their operations before determining how much a workman should do.

> Our experiments have been of two kinds: first, the reduction of the control and operation of machines from rule-of-thumb to science; and, second, the examination and standardization of human actions and work with relation both to maximum efficiency and maximum speed.
>
> In changing a machine from rule-of-thumb both in design and in running to a science, first note carefully all the defects of the machine; that is, all things likely to get out of order and cause bad work or stoppage. Next chase down and analyze each defect and note the effect that it has upon the time problem; that is, upon the quantity and the quality of the output. Then centre upon the most important defect and correct it; then follow up in regular order of importance.
>
> Next study all the elements as they affect the speed and output, whether they are connected with the machine

[5] F. B. Copley, *Frederick W. Taylor*, Vol. I, page 204. New York: Harper and Brothers, 1923.

> alone or with the man and the machine combined; then find the one or more elements which limit the speed of output; centre on the most important, and correct them one after another. This generally involves a combination of study of the man with the machine and involves in many cases minute time observations with the stop watch.[6]

Taylor's experiments with his machine tools were conducted in what was, in effect, a laboratory. All of the operating conditions were under control. He was able to maintain an even flow of power, and his cutting tools were all of the same quality of steel, tempered exactly alike and ground to the same shape. The workmen who operated his machines were first-class men who carried out his instructions carefully because of his leadership and his offer of a financial incentive in the form of additional wages.

But the moment he was ready to translate his results to actual shop conditions, he faced the problem that often puzzles manufacturers desiring to do on a large scale what they have been able to develop in an experimental laboratory.

> First of all, he had to standardize all the shop conditions—bring them up to the same standard that had obtained in his 'laboratory.' This made it necessary for him to take the tool grinding and dressing out of the hands of the individual workmen; and as there must be not only standard cutting tools but also standard bolts, clamps, dogs, calipers, gages, scales, dividers, etc., and all these tools must be on hand when wanted so that the workmen would not lose time chasing them up or be forced to resort to tools other than standard, Taylor had to establish a tool room for their systematic care, storage, and issuance. And it also was necessary for him to develop standard practice for such things as caring for the belting and oiling the machines. Certainly it was not until all this standardization work was done that he could begin to make proper use of his metal-cutting and motion-study data.

[6] F. B. Copley, *Frederick W. Taylor*, Vol. I, page 253. New York: Harper and Brothers, 1923.

> But just how could he make use of these data? Plainly it involved getting the right materials and the right tools in the right condition to the right man at the right machine with the right instructions at the right time. All causes for delay must be guarded against. As far as possible, the flow of work must be continuous. Therefore, all the work of the shop had to be carefully planned in advance.[7]

Taylor's experiments illustrate one significant characteristic of industrial standards. They are set, not by custom, public opinion, or authority, but by research. The desire to achieve economy through uniformity has been reflected in the activities of the standards committees of trade associations and technical societies, but standards eventually agreed upon are, nonetheless, the products of research.

Operating standards. Operating standards may be developed for each of the following items:

1. Material.
2. Equipment (machines, tools, workbenches, chairs, handling equipment).
3. Working conditions, including heat, light, and ventilation.
4. Methods of performing work.
5. Procedures.

The need to develop standards for materials and the relation between materials and performance are illustrated by the difficulties with castings encountered by a large manufacturing company. Its foundry was plagued by shortages in required grades of coke and in pig iron. The use of coke of a different grade and of a higher proportion of scrap metal resulted in castings that were unsatisfactory. Not only were castings scrapped, but many of those salvaged required additional work such as the welding of sand holes.

The following case illustrates the application of standard-

[7] F. B. Copley, *Frederick W. Taylor*, Vol. I, page 259. New York: Harper and Brothers, 1923.

ization to materials and equipment. A company making metal products had a number of assorted punch presses, one of which ran 10 per cent slower than the others. Its speed was brought into line with the rest. The materials from which the punches were made numbered 21 kinds and grades, which were bought in 94 different sizes. These were reduced to two grades of brass sheet and strip. The standardization of these materials required the alteration of 112 blueprints. A study was made to determine the advisability of replacing the sheet brass with strip. It was found that on the average, fifteen minutes were required in the storeroom for cutting material from the sheets for a lot of 500 punchings. In addition, five minutes were necessary to pick up this material and to start it in the die. Accordingly, changes were made to use strip.

Moreover, at the beginning of the standardization procedure, it was discovered that 207 different punch holders were in use. By redesigning, their number was reduced to seven. As part of the standardization, a single safety guard for all the open blanking dies was developed.

After the standardization of the drilling operation was started, it was found by experimentation that a spindle speed of 3,500 revolutions per minute was needed for certain materials. The speeds actually possible were far below this rate, and varied from drill to drill. The extent of this variation and the necessary respeeding are shown in Figure 10.

In drilling brass, the higher speed decreased the amount of "hogging" and burr, and decreased the wear upon the drills. For material of a given thickness, the time required decreased 32 per cent as the spindle speed increased from 990 R.P.M. to 3,700 R.P.M.

The work of machine standardization involves raising the efficiency of each machine so that it will produce each type of work effectively. Where belts are used, much can be accomplished by determining the best type and usage for supplying the power desired. Standardization further requires a study of the speeds and feeds at which machines should be

Drill Number	Number of Spindles	Present Maximum Spindle Speed	Proposed Maximum Spindle Speed
1	8	1,942	3,500
2	5	1,593	3,500
3	3	1,643	3,500
4	5	1,610	3,500
6	6	1,344	3,500
7	8	1,510	3,500
9	8	1,933	3,500
10	3	2,008	3,500
11	1	1,162	3,500

Figure 10. Drill Press Spindle Speeds

operated, as well as the elimination, where practicable, of differences in speeds and feeds so that there will be greater flexibility in assigning work to these machines.

The first step in the standardization of tools is a classification of them. Tools can be divided into two major classes, namely cutting tools and auxiliary tools. Auxiliary tools include all tools in the shop other than machines and cutting tools—that is, devices of all kinds, hand tools, and other mechanisms used by the worker in performing his job. There is an astounding lack of standardization of these in the average plant. In many instances workers are required to supply their own tools; such a system results in almost as great a variety of tools as there is of workers. Where such a condition exists, there is bound to be inefficiency. For example, it was found that in one company a four-pound soldering iron was used to solder a wire 1/64 of an inch in diameter. In another case workers were found using 12-inch scissors where the work could best be done with 4-inch ones. A fine example of tool standardization can be seen along the assembly lines of almost any large automobile factory. For example, wrenches have been devised to reach nuts located in inaccessible parts of the motor.

Operating standards have, perhaps, been more difficult to establish and maintain for working conditions than for any of the other items. Light, heat, and ventilation are closely associated with natural sources in which there are considerable variations. However, much improvement has been made in recent years in approaching the goal of "controlled conditions." The advance of air conditioning and of artificial lighting should enable the influence on output of variations in light, heat, and ventilation to be minimized.

The development of standard procedures and methods of performing work will be treated in the next chapter.

Use of standards. Standards provide the bases for planning and the yardsticks for control. Performance standards, expressed as time allowances, are essential for estimating costs, establishing delivery dates, scheduling work for machines or departments, machine loading, and determining the number of employees required. Operating standards must be established and maintained if performance standards are to be valid.

Standards also have value in the development of system. For example, standard ordering points and ordering quantities enable inventories to be controlled in a routine manner without requiring executive decision each time an item of stores is low. Standard procedures establish the manner in which recurring activities are to be carried out. They can be developed for such routines as requisitioning materials or additional workers, ordering tools, and dealing with grievances.

As yardsticks for control, standards enable the measurement of efficiency. The comparison of actual results with standards may be used to measure effectiveness of the sales force or of a department's operation as well as the efficiency of a machine or individual worker. Standard costs, budgets, or quotas are broad standards that may be used for control; standard time allowances, narrow ones. Finally, standards are a prerequisite to, and make possible the use of, effective financial incentives.

In summary, performance standards are essential for planning, manning, and control. Performance standards are valid only after operating standards are established. Industrial standards are not constant but are the best for a given purpose at a given time. Standards are not self-policing. Just as they should be established initially only after careful research and study, so must continuous study and research be undertaken to improve them. Once established, management must see that they are adhered to. Properly established, maintained, and improved, standards provide the foundation for good management.

Questions:

1. Do the seats in your classroom represent an application of industrial standardization?

2. From the point of view of adaptability, should a single make and model of automobile be adopted as standard equipment for company salesmen?

3. How frequently would changes in make, model, and body design be justifiable in the cases of salesmen's cars and delivery trucks?

4. A complete development of operating standards includes hiring specifications for use by the employment department. Do such standards yield the same degree of control as material specifications do for the purchasing department?

5. In specifying materials, what compromises with functional fit are necessary? Apply your analysis not only to raw materials but also to such items as safety shoes for workmen.

CHAPTER 9

Methods and Motion Study

THE program by which operating standards are developed includes methods analysis and motion study, in addition to the analysis and standardization of machines, tools, and working conditions. As used in this chapter, the term "methods analysis" applies to the study of the complete sequence of operations in a manufacturing process or office procedure; the term "motion study" applies to the detailed study of the movements of a worker in performing a job at the workplace. The term "work simplification" is often used to embrace both methods analysis and motion study. Methods analysis in turn is frequently called operations or process analysis, or in offices, procedures or systems analysis.

Methods analysis. Methods analysis involves: (1) detailed description of the present method of performing work, (2) study of each step of the method to determine how it can be improved, and (3) development of an improved method.

The detailed description of the steps involved in performing work can be portrayed by process charts. These show in graphic form every operation, material movement, and other parts of the process. A good example of a procedure described graphically by a process chart may be seen in Figure 2. In preparing a process chart the analyst must observe the course of the material through the office or shop and record what happens to it. Methods analysts have developed standard symbols to record the most frequently recurring steps or events. The common events and the generally accepted symbols for them are shown in Figure 11.

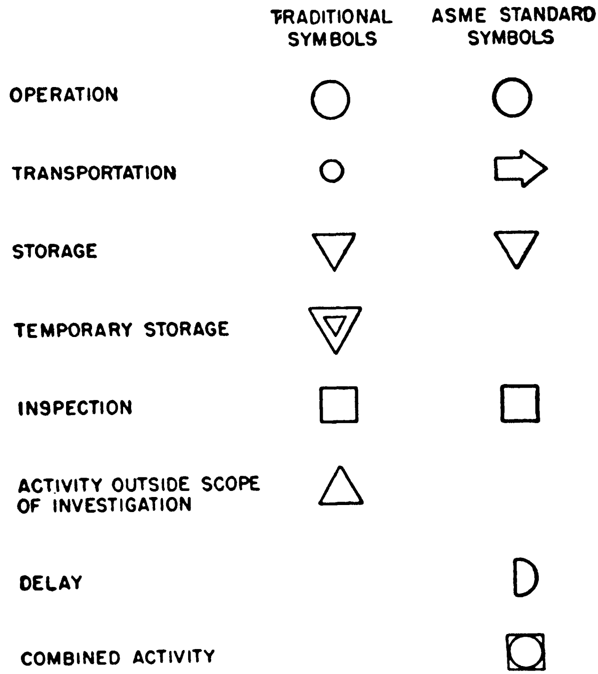

Figure 11. Traditional and ASME Standard Symbols

Process charts may be constructed to give as much detailed information as is needed. For some purposes a simple process chart, such as that for the claw hammer, Figure 2, is sufficient. At the other extreme the chart may give detailed information concerning each event: operations may be numbered, described, and time allowances given; transportation symbols may include letters to indicate the mode of transportation, and the distance moved may be recorded; notation may be made of duration of storages; and the type of inspection may be noted.

After complete information on the events of a process has been obtained, the analyst must subject each event to careful analysis. Having determined what is to be done, he must ask why. Is it necessary? Can it be eliminated by using different material, tools, methods, or design, or by combining it with another operation? If an event can be eliminated, the process will obviously be improved. Even if it is necessary, it may not be performed in the best way. The analyst must determine if an event can be performed in a better or less costly manner, by raising such questions as: Can distances be reduced? Can the speed be increased? Could storage time be cut down? Could improved equipment be substituted? For example, material may be received by box-car, loaded on hand trucks that are pushed manually to a receiving and storage area some distance away, unloaded, counted, inspected, and then piled manually in storage bins or racks. The same material, inspected before shipment, might arrive on pallets and be moved from box-car to storage area and stacked in one operation by fork-lift truck. Whether such a change would pay can be determined by an economy study.

Motion study. The detailed study of the movements of a worker in performing a job may be made by "simple motion study" or by "micro-motion study." Simple motion study consists of the anaylsis of motions obvious to the human eye. Frederick W. Taylor utilized simple motion study together with time study in his research into the art of cutting metals. "Pick out all useless movements and discard them. Study, one after another, just how each of several skilled workmen makes each elementary movement, and with the aid of a stop watch select the quickest and best method of making each elementary movement known in the trade." [1]

Frank and Lillian Gilbreth developed the micro-motion technique for studying elementary motions that required only fractional parts of a minute. In this method the Gilbreths used the motion-picture camera to photograph the actions of the operator with a fast-moving clock (microchronometer) within the field of vision. The film could then be analyzed by running it slowly through a stereoscope, which permits the eye to see about six consecutive pictures, or through a projector.

[1] F. B. Copley, *Frederick W. Taylor*, Vol. 1, page 227. New York: Harper and Brothers, 1923.

This technique, like that of simple motion study, has since been refined.

Both simple motion study and micro-motion study require the division of work into fundamental elements. These may be presented graphically by various forms of process charts: for work requiring the constant attention of an operator, a motion chart or an "operator right- and left-hand" chart should be used;[2] for the tending of a machine (in contrast to continuous operation of one, as in typing), a man-machine chart should be used. The motion chart, shown in Figure 12, indicates how many elements may be discovered in such a simple job as the operation of an Elliott-Fisher machine. Such information will often assist in eliminating unnecessary manual motions and in revealing the need for jigs or fixtures to hold the work so that both hands may be kept busy. If a particular operation involves the tending of a machine, the analyst will want to know how much of the time the machine is working and how much of the time the man is working. The man-machine chart shows in parallel columns the steps performed by the operator, those performed by the machine, and the time required for each.[3] Each of the charts mentioned will be more detailed than the ordinary process chart, because it shows the separate steps or elements involved in the completion of any job studied, whereas on the process chart such a job appears as merely one step or symbol in the process.

The elements into which the operation may be broken down for analysis may be much finer subdivisions of the motion cycle than those shown in Figure 12. The Gilbreths have identified seventeen basic elements, which they have called "therbligs" (derived from the name "Gilbreth").[4] Among

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[2] An elaboration of the motion chart is the "simo chart," as used in the Gilbreth technique. This consists of a chart showing in colors the relative time taken for each "therblig" by each hand or leg.

[3] For a more detailed presentation see Ralph M. Barnes, *Motion and Time Study*. New York: John Wiley and Sons, Inc., 1949.

[4] For the complete list, see L. P. Alford and J. R. Bangs, editors, *Production Handbook*, page 578. New York: Ronald Press, 1944.

Left	*Both*	*Right*
	1. Pick up Registration Sheet with old and/or new stock folded inside.	
2. Place stock at center on slate.		3. Release slate clip and slide registration sheet under clip. (Drop clip with foot pedal.)
*4. Lift up top sheet.		*5. Insert carbon.
6. Hold down sheet.		7. Pull carriage forward.
	8. Locate at left.	
	9. Type initials.	
	10. Locate over date space.	
	11. Type date.	
	12. Locate carriage at Certificate Numbers Canceled column.	
	13. Type certificate number.	
	14. Tabulate to Shares column.	
	15. Type number of shares.	
16. Turn old certificates.		17. Space to next line.
	Repeat Nos. 12 to 17, inclusive, for each old certificate.	
	18. Locate carriage at Certificate Number column registered (new).	
	19. Type certificate number.	
	20. Tabulate to share column.	
	21. Type number of shares.	
22. Turn new certificate.		23. Space to next line.
	Repeat Nos. 18 to 23 for each new certificate.	
	24. Locate at end of Canceled Shares column.	
	25. Type total from register.	
	26. Locate at end of New Share column.	
	27. Type total from register.	
		28. Push carriage back.
	29. Separate sheets and pull carbons.	
		*30. Place carbons at right.
	31. Fold certificates in sheet as clip is released.	
	32. Place sheet and certificates at left.	

* Irregular operations.

Figure 12. Motion Chart for Operation of Recording Stock Registrations on Elliott-Fisher Machine (Hand Operated).

the more important of the elements of the operation are the following:

Grasp
Transport loaded
Position
Assemble
Use
Disassemble
Release load
Transport empty

Laws of motion. From their study of fundamental elements and characteristics of motions, the Gilbreths formulated certain "laws of motion," some of which are:

Both hands should preferably begin their "therbligs" simultaneously, and complete their "therbligs" simultaneously.

Motions should be in opposite and symmetrical directions instead of in the same direction.

The best way to perform an operation is almost always the method containing the fewest "therbligs."

Motion economy results when motions are eliminated, combined, reduced, or made more easy. There are a number of common devices used to economize motions, some of which are illustrated below:

Grasp. The principal rule for improving the grasp element is to make it easy to perform. The use of "holsters" to hold soldering irons, riveting guns, and screw drivers with the handles exposed makes the grasp easy. So does the familiar fountain-pen desk set. A cup-shaped receptacle or uneven surface facilitates the grasp in picking up coins, screws, and other small objects. Dispensers that supply one paper towel or cup at a time in an accessible position are additional examples.

Transport loaded. The rules for improvement are: reduce the weight of the object moved; shorten the distance; substitute sliding for carrying; or introduce facilitating equipment. Time is a function of weight. It takes longer to move a heavy object a given distance than it does a lighter one. For this reason, tools are frequently suspended with counterweights. Time is also a function of distance. The latter is reduced by placing the most frequently used tools, supplies, and materials in the handiest locations.

Position. A useful rule is to provide physical devices to guide or stop movements. V-shaped guides provide broad targets at the open end and lead the motion to the proper position automatically. The holster not only makes grasp easy but, through its cone shape, eliminates careful positioning in replacing the tool. Stops at appropriate locations are likewise useful in making positioning easy. A simple illustration is found in the paper cutter. In drilling, the location of the hole must be laid out, the center marked, and the drill point positioned on it. A drill jig eliminates layout and center punching, and makes positioning easier.

Analysis of each of the other fundamental elements will also disclose ways of improving them. Hold is sometimes considered a "therblig." Wherever found it should be questioned because the use of the hand for holding is wasteful.

Characteristics of motions. In the process of studying motions, investigators have had to consider physical motions in terms of the human body. Such motions have been described or classified in several ways, the most significant of which are the five major classifications developed by the Gilbreths as follows:

Class 1 Finger motions.
2 Finger and wrist motions.
3 Finger, wrist, and forearm motions.
4 Finger, wrist, forearm, and upper-arm motions.
5 Finger, wrist, forearm, upper-arm, and body motions.

Movements in these classifications may be broken down further according to the manner in which the motion is made. For example, the third-class forearm motion may be made with the elbow acting as a pivot, or similar to a ball and socket joint, or it may be a twisting one. The first occurs when the forearm is simply moved sideways or up and down with the elbow used as a hinge; the second, when a circular forearm motion is made as in spinning a wheel; the third, when a twisting motion is made as when tightening the handle of a safety razor. Somewhat similar subdivisions, in each case associated with a part of the body, such as trunk, hip, leg, knee and ankle, may be made in the fourth- and fifth-class motions.

Improvements in the workplace. One of the most important points for the analyst to study is the physical workplace. Any improvements in this respect make future savings automatic. A trained observer can often see at a glance what changes should be made in the machine, workbench, tools, or equipment holding the materials, in order to eliminate or shorten the movements of the operator. It is not difficult to see that a worker who must walk fifteen or twenty feet to get his material or to lay down his finished work could increase his output with a better arrangement. This portion of the analysis occasionally results in the substitution of entirely new methods of performing the work, or at least in moderate changes in equipment and method. Consequently the connection between motion study and the development of standard equipment is apparent. If the word "standard" as used in modern management is defined as a "carefully thought-out method of performing a task," or as "the best method, condition, or specification that can be devised at the time, taking into account all limiting factors," it is obvious that the type of research under discussion is the logical means of securing such working conditions as may be termed "standard." Not only do such conditions help to make proper methods and motions automatic, but they also provide the essential basis for requiring that operators accomplish a definite task.

Workplace improvement requires attention to normal and maximum working areas. The normal working area for each arm is determined by pivoting the forearm from the elbow in a third-class motion; the maximum working area, by pivoting the arm from the shoulder in a fourth-class motion. The normal and maximum working areas in the horizontal plane are shown in Figure 13.

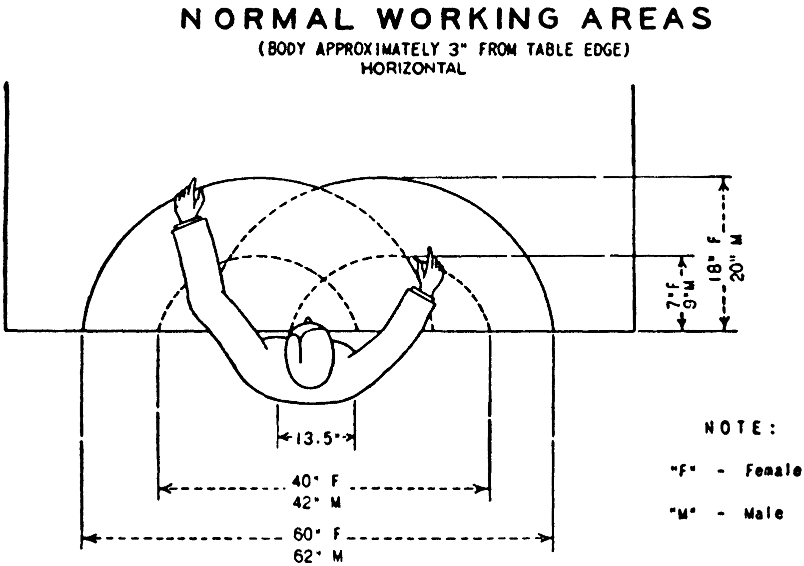

Figure 13. Normal and Maximum Working Areas, Horizontal.

For each arm there are also normal and maximum working areas in vertical planes (see Figure 14). These, in combination with those on the horizontal plane, may be visualized as portions of spheres. The most frequently used tools, supplies, and materials should be placed within the normal area; the less frequently used ones, within the maximum area.

In determining whether the workplace can be improved, the following guides may be used:

Definite fixed stations should be maintained for all tools and supplies, because such an arrangement develops automaticity and rhythm. Since these habits of proper work methods replace conscious, mental direction, they require less effort.

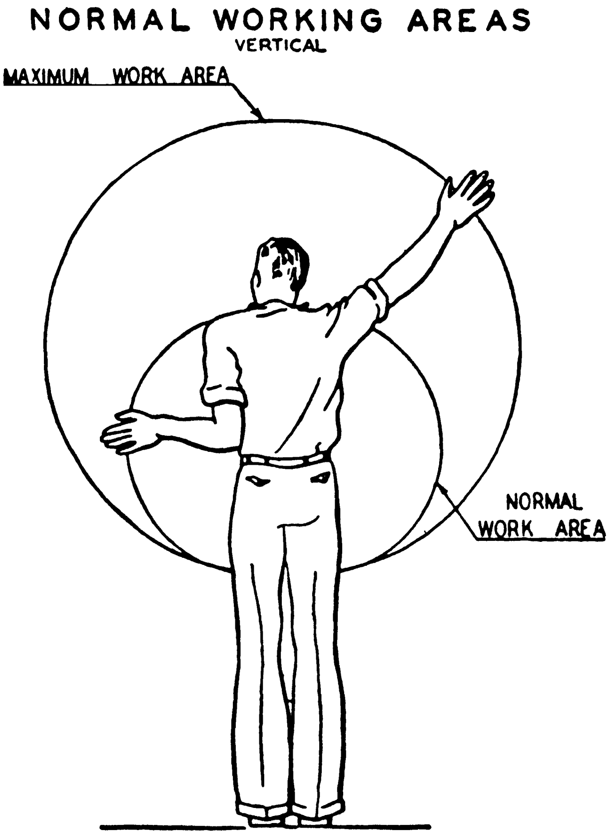

Figure 14. Normal and Maximum Working Areas, Vertical.

Whenever possible, tools should be pre-positioned. When they are not in use, the tools should be stored or placed in such a position that when they are next wanted, they may be grasped in the same manner as they are held when being used.

Containers for holding supplies should preferably be arranged at an angle of about 30 degrees so that parts may be taken from them easily.

Placement of supplies of materials should be arranged with regard to the sequence in which the parts are used. The proper placement of materials and tools is also governed, to a large degree, by the law that "motion of the hands should be in opposite and symmetrical directions." In order to permit the hands to move symmetrically and simultaneously, it is frequently necessary to arrange duplicate stations for the parts and tools, one on each side of the workplace.

Materials and tools should be located slightly higher than the working point, and the latter should be low enough so that the arms are at a comfortable angle. It is often desirable to have the working point at such a height that the worker may sit or stand at his pleasure.

In order that the completed article may be released by the operator at the moment of completion, there should be installed wherever possible a "drop delivery," which will deliver the article to its destination by gravity.

Questions:

1. Prepare a simple motion chart of your particular method of shaving.

2. To what extent should the motion study technique adopted reflect the volume of production of the item in question?

3. Which method would be applicable to the assembly of a vacuum cleaner?

4. Identify the therbligs involved in replacing an electric light bulb; in erasing writing from the blackboard and writing on it.

5. Analyze a dental chair and accessory equipment as a workplace.

CHAPTER 10

Time Study

THE greatest credit for the wide use of time study in modern factory management and for the increasing adaptation of the principles of similar analysis and experiment to the sales and financial divisions should go to Frederick W. Taylor.[1] According to Taylor's biographer, F. B. Copley,[2] Taylor's application of scientific methods to management began when he tried to define his problem as a foreman at Midvale. He finally stated his job of machine-shop foreman as that of "removing metal from forgings and castings in the quickest time." Yet he fully realized that he did not know what the output of the man and the machine ought to be. "He found that his master task or problem of getting metal out in the quickest time naturally divided itself into two principal sets of detail problems; the one having to do with the mechanics of the shop's equipment, and the other, with the workers' operation of that equipment.[3]

At the very outset, Taylor was able roughly to puzzle out and define the purpose and nature of the question to be solved. However much he may have groped in the early days of his experimentation, the history of the steps which he took gives us a rather clear picture of how a manager may follow the

[1] Others who have made contributions are Dwight V. Merrick; Carl G. Barth, Henry L. Gantt, and H. King Hathaway; and Mrs. Lillian M. Gilbreth and the late Frank B. Gilbreth, who developed the technique of micromotion study.

[2] F. B. Copley, *Frederick W. Taylor*. New York: Harper and Brothers, 1923.

[3] *Ibid.*, p. 206.

so-called scientific method. He first determined what had to be done; then he analyzed how it might be accomplished. In short, he subdivided the complete job into smaller detailed jobs, for a problem of considerable size cannot be thoroughly understood or solved until it has been analyzed in detail.

That Taylor fully recognized the importance of subdividing or breaking down a problem into small elements for purposes of analysis, is brought out clearly by Copley. This principle is fundamental to accurate time study.

> Now, there are jobs where the difficulty of maintaining the desired quality of work is so great that the time element is comparatively negligible, but they are the exception which proves the rule that, because of the relation between speed and economy, a proper standard of accomplishment is fundamentally one of speed or of the time needed to produce work of the desired quality. Hence Taylor's "laboratory" was fundamentally concerned with determining standard times. And that this was a problem possible of solution only by Taylor's method of job analysis should be clear when it is considered that you cannot determine with accuracy the total time a job should take until you resolve it into its elementary operations and time these. Once having determined these elementary times, however, you have data for any new jobs that may come into the shop, since all jobs simply represent different combinations of the same elements.[4]

Significance of a definite task. The importance of a clear-cut task both to the happiness of workers and to the effectiveness of their supervision has been well expressed by Mr. Frederick W. Taylor himself:

> There is no question that the average individual accomplishes the most when he either gives himself, or some one else assigns him, a definite task, namely, a given amount of work which he must do within a given time; and the more elementary the mind and character of the individual the more necessary does it become that each task shall

[4] F. B. Copley, *Frederick W. Taylor*, page 257. New York: Harper and Brothers, 1923.

extend over a short period of time only. No school teacher would think of telling children in a general way to study a certain book or subject. It is practically universal to assign each day a definite lesson beginning on one specified page and line and ending on another; and the best progress is made when the conditions are such that a definite study hour or period can be assigned in which the lesson must be learned. Most of us remain, through a great part of our lives, in this respect, grown-up children, and do our best only under pressure of a task of comparatively short duration.

Another and perhaps equally great advantage of assigning a daily task as against ordinary piecework lies in the fact that the success of a good workman or the failure of a poor one is thereby daily and prominently called to the attention of the management. Many a poor workman might be willing to go along in a slipshod way under ordinary piecework, careless as to whether he fell off a little in his output or not. Very few of them, however, would be willing to record a daily failure to accomplish their task even if they were allowed to do so by their foreman; and also since on ordinary piecework the price alone is specified without limiting the time which the job is to take, a quite large falling off in output can in many cases occur without coming to the attention of the management at all.[5]

Perhaps the most prominent single element in modern scientific management is the task idea. The work of every workman is fully planned out by the management at least one day in advance, and each man receives in most cases complete written instructions, describing in detail the task which he is to accomplish, as well as the means to be used in doing the work. And the work planned in advance in this way constitutes a task which is to be solved, ... not by the workman alone, but in almost all cases by the joint effort of the workman and the management. This task specifies not only what is to be done but how it is to be done and the exact time allowed for doing it. And whenever the workman succeeds in doing his task right, and within the time limit specified,

[5] Frederick W. Taylor, *Shop Management*, page 69. New York: Harper and Brothers, 1903.

> he receives an addition of from 30 per cent to 100 per cent to his ordinary wages. These tasks are carefully planned, so that both good and careful work are called for in their performance, but it should be distinctly understood that in no case is the workman called upon to work at a pace which would be injurious to his health. The task is always so regulated that the man who is well suited to his job will thrive while working at this rate during a long term of years and grow happier and more prosperous, instead of being overworked. Scientific management consists very largely in preparing for and carrying out these tasks.[6]

Types of task in use. The most clear-cut illustration of the various kinds of performance standards against which we measure our results is to be found in sports. One who takes part in a game may engage in as many as three kinds of competition simultaneously:

1. The endeavor to beat his opponent.
2. The comparison either with perfection or with a carefully established par.
3. The comparison with what he considers a reasonable showing for himself.

In golf, all three forms of competition are involved. On every hole the player compares his performance with par. If playing a match, he also tries his skill, or luck, against that of his opponent. But the real task which a golf player is always seeking to accomplish is to equal or beat that score which he considers as a reasonable performance, based on his own past record. This task may be thought of as par plus a handicap. The task here represents the overcoming of certain obstacles in a certain number of strokes. Time is not a factor.

In track events, however, a runner endeavors not only to outdistance his rivals but also to cover a certain distance in a time better than the standard he has set for himself. A runner

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[6] Frederick W. Taylor, *The Principles of Scientific Management*, page 39. New York: Harper and Brothers, 1911.

has two standards against which to compete. *One,* the world's record for that distance; the *other,* a reasonable performance for a man of his capacity and training. In the decathlon, for example, the world's record constitutes the base for converting into points the actual performance in each event. When finished, however, a competitor will judge his entire performance by a task considerably lower, and will take into consideration any special weather conditions which might have affected the results.

The same dual nature of performance standards is evident in bowling, trap shooting, and in a player's batting average in baseball. The final or ultimate standard in each case is perfection. But the standard against which a man actually competes (that is, his working standard or task) is lower.

In the classroom two kinds of performance standards are evident. One is the assignment which the student is asked to prepare. The year's work is divided up into daily tasks, which represent the teacher's idea of the quantity of work the student should accomplish. The student's grades in the classroom and in his examinations are a measure of quality. Here again we encounter a series of standards: perfection, or 100 per cent, is the ultimate standard and the basis for grading; a passing grade of 70 per cent represents the dividing line between credit and no credit; in addition, nearly every student assigns himself his own level of performance which he feels he ought to attain.

In our homes the tasks are definite enough as to quantity of work, but more indefinite as to quality and time. As youngsters few of us escaped the assignment of a series of jobs to be done either before going to school or after coming home. Mowing the lawn, feeding the dog and the pony, and putting out the ashes and the cat are typical.

In business, various forms of management tasks are encountered. In a good organization, each man has a carefully prescribed job, so that he knows the specific duties which he is expected to perform. The assignment of work should indicate clearly to him the nature of his job, or what he is to do. How much he should do in a given time or how well he should do the work must be covered separately; the first, by output, and the latter, by quality standards.

Among the quantitative measures of the amount of work which a manager requires are the sales quotas covering the volume of sales expected from each salesman, territory, or branch; the shipping schedules assigned to the factory superintendent; the task or number of pieces which a machine operator is asked to do per hour or per day. In the last case, the task may be expressed either in time allowed per piece or in the number of pieces expected per hour.

Tasks representing quality of workmanship are illustrated by the tolerances given to a machinist within which he must keep the dimensions of his finished piece; by samples representing satisfactory color or finish; and by budgets representing reasonable or forecasted expenditures. The last may cover a salesman's traveling expenses, the electric current purchased for the factory, or a total of all the expenses allotted to a given department for a budget period. For instance, the buyer of a hosiery department in a department store is told by the store manager that he is expected to keep the salaries of his sales force within 4 per cent of the dollar sales.

Tasks must reflect changes in conditions. The variables affecting performance are often numerous. Consequently, a task must be based upon a given set of conditions, in which any substantial change should be reflected in the task assigned. For example, in judging the performance of a runner, such variables as mud, wind, presence or absence of starting blocks, and number of turns in the track must all be considered. Records are only recognized officially after a check has been made of the influence of factors that might favor the runner.

Time Study: Setting Output Standards

Time study involves the taking with a stop watch of observations upon an operation after it has been broken down into elements. A good statement of the purposes of time study is the following:

> To subject each operation of a given piece of work to a close analysis, in order that every unnecessary operation may be eliminated and in order to determine the quickest and best method of performing each necessary operation; also to standardize equipment, methods, and working conditions; then, and not until then, to determine by scientific measurement the number of standard hours in which an average man can do the job.[7]

This device of management can be applied to all types of work in the shop and office where the volume is sufficient to warrant study and where the work is sufficiently repetitive to make analysis and measurement possible. Since in the past so much difficulty has been caused by the assignment of time-study work to those without the analytical ability and all-around development to perform it properly, it is important to emphasize that the analysis is worth making only when done carefully. Used as a mere device to set rates or to add an aura of science to decisions that are actually arrived at by arbitrary methods, it is worse than useless, for this leads to distrust by the working force. To be properly qualified for the job, time-study men should be trained first in the philosophy and technique of motion study. Unless the analyst is sufficiently "motion-minded" to recognize instinctively motions that are ineffective, he is not likely to secure the maximum improvement in the workplace and methods; nor is he able to discriminate in recording his time data between those that represent properly made motions and those that represent wasteful motions. It is understood, of course, that the observer must have sufficient personality and experience to overcome the antipathy of the worker being observed. Such antipathy is to be expected, because soldiering is the natural

[7] Stewart M. Lowry, Harold B. Maynard, and G. J. Stegemerten, *Time and Motion Study*, page 6. New York: McGraw-Hill Book Company, Inc., 1940.

human response to suspicion and fear. In order to prevent soldiering from distorting the time study, the observer should attempt to establish confidence between the operator and himself, so that the former will feel that he is part of an experiment to which he is contributing his specialized knowledge and experience.

Types of time studies. Time study differs in its application according to the nature of the work to be studied. The three principal types of time study are job time-studies, operation time-studies, and production time-studies. Where work is repeated on long runs, as in molding the cylinder block for an automobile, task times may be set by job time-studies. Standard parts produced intermittently in lots or batches likewise lend themselves to the use of job time-studies. In setting task times by this method, the job is sub-divided into elements and the time required for each of the elements in the cycle is recorded while the job is being performed. When task times are set from job time-studies, each new job introduced into the shop must be timed.

Whenever the same operations are performed on a great variety of products, it is extravagant to study each job separately. In such cases, operation time-studies may be used to establish standard times for the fundamental elements involved in the operations. For example, operations such as punching, drilling, and milling may be common to many jobs. By timing the fundamental elements of an operation, as performed on a wide range of selected jobs, basic data are obtained. When these data are tabulated, the tendencies in them will be clearly evident. For example, if the drilling operation is being studied, the time required for the drill to penetrate a steel plate will vary with the thickness of the plate and the diameter of the hole. In contrast to these data, which vary according to some factor affecting the operation, certain times are constant in each job. A classification of the figures for all of the studies on a given operation will reveal whether a particular element belongs among the variables or among the constants.

The constants may, of course, be handled quite simply, because they are uniform for all jobs, or at least for certain classes of jobs. The variables, however, must be plotted on graph paper in order that irregularities may be smoothed out and a standard curve adopted. Proper selection of the jobs to be timed makes it possible to determine just enough points to find the shape of each curve and thereby reduce the cost of making the study.

A production time-study is a form of time study covering a large sample of work performed continuously over a long period of time. Such a study differs from the others in that for a production time-study the job is not sub-divided into fundamental elements for timing. Rather the purpose of such a study is to identify, segregate, and time events that are not part of the regular job cycle. Production time-studies are used to secure delay allowances; to check the accuracy of task times set by other types of time study; and to set the task for automatic machines.

Type of operator studied. The earlier practitioners of time study believed that the most accurate basis of measurement was the performance expected of an expert because of his greater consistency. Consequently Taylor and others made their time studies on the work of skilled men. Although the task or time allowance actually announced to the workers was at a level of performance that average workers ought to maintain without injury to their health, the use of expert operators aroused suspicion of the times established. An additional difficulty was the inability to select a skilled operator for operations that were performed by one or two workers only.

Several techniques have been developed to adjust times for variations in the skill or pace of workers. These are leveling, speed rating, and effort rating. Under each of these, either the element times or the cycle times actually observed are adjusted upward or downward in accordance with the time-study man's judgment of the deviation of actual performance from the predetermined "normal." Theoretically the adjusted times for any operator represent the level of performance normally expected of the average man. So long as the workers have advanced beyond the learner stage, it makes no difference what type of operator is observed because the adjustment process theoretically equalizes their times.

Another method is to make sure that the data represent only those operations properly made (that is, according to the laws of motion), and then to judge the pace of the operator by comparing the elements of his job with similar ones in other jobs that have been studied.

It is generally believed that in a shop where the management is of average quality, the pace of dayworkers will be approximately half of their speed if they work on incentive after the operation has been analyzed and standardized. It is important, therefore, to consider whether the studies are being made on dayworkers or on pieceworkers.

Time-study equipment. The equipment required for time analysis is relatively simple. In fact, an analyst can get along with a stop watch, a speed indicator to determine the speed of shafting and pulleys, and a slide rule. In addition, of course, he will need properly drawn forms on which to record the data. For practical purposes, the ordinary stop watch, the dial of which is graduated into sixty divisions, is not suitable. Time-study data should be taken with either a "decimal-hour" or a "decimal-minute" watch. The dial of the former is divided into one hundred spaces, each of which represents .0001 hour, and the dial of the latter is divided into hundredths of a minute. Although the slide rule is not essential, it is very helpful in making the computations.

Taking the times. The timing of work falls into two divisions: the analysis and timing of the operation itself, and the analysis and timing of the allowances for preparation, unavoidable delays, and fatigue.[8]

Before the observer actually records any data, he must determine the elements, or groups of elements, that are to be timed. Obviously these factors must be clearly defined so that as he times them repeatedly, his data will be comparable. The end of each group of elements should be marked by a distinctive noise or motion. Elements shorter than .02 of a minute are too short to time accurately with a stop watch. For practical reasons, therefore, it is necessary to find groups small enough for effective analysis and yet large enough for accurate timing.

The problem of how many observations to take on a given job or operation is a statistical one that concerns the adequacy of the sample. The correct answer depends, of course, upon the variability of the work itself and the consistency of the times recorded. It is apparent that the greater the consistency, the fewer the observations need to be. In such instances twenty-five to fifty observations are likely to be sufficient. But where the variations are wide or the jobs are long, as in weaving, it may be necessary to prolong the study from one to ten days. Although it has often been stated that a sample of an hour's work will suffice in many shops, it is obvious that no general rule can be followed blindly.

In observing and recording the times, it is of extreme importance that the observer should be able to recognize subconsciously the incorrectly made motions so that he may distinguish these in his observations. He may, of course, segregate either the times representing correct motions, or the times for incorrect motions.

The watch may be handled in three different ways. It may be permitted to run continuously; it may be stopped after each element; or it may be so operated that, without stopping the watch, the hand is snapped back to the zero position at the

[8] Actually, some information concerning preparation, clean-up, and delays is usually recorded at the time the operation itself is studied.

end of each element or group of elements. Of these, the first is the most practical for a beginner, because it does not waste his time, and yet errors in making one observation will be compensated for elsewhere. This method requires, however, that each figure be subtracted from the succeeding one. The second method is scarcely used in practice, except for very short elements. The third is entirely practical for skilled observers, and has the great advantage of eliminating the need for subtraction, a necessary task under the first method.

Finally, certain mistakes must be avoided. One of the most serious of these is variation in the quality of the work performed during the taking of the study. The proper solution is to have a responsible inspector pass upon all the work performed during the time-study analysis. If there is no inspection department with clear-cut standards of quality, some other means must be discovered for accomplishing the same result.

Even more important than the errors made is the conscious stalling of the worker unless his confidence has been obtained and he is made to feel that he is taking part in a joint experiment which will not work to his disadvantage. The necessity for analyzing the correctness of each motion at the time it is observed has already been emphasized. Without such analysis, the figures will represent bad work as often as they will good, and the median selected from them will be almost meaningless.

When the volume of work fluctuates and the flow is not continuous, management should provide a uniform amount of work by using one of the following methods: taking steps to level out fluctuations in volume (if such steps are possible); developing elasticity in the working force by hiring part-time workers, or by arranging for the transfer to other departments of those not needed; or, developing a backlog of work that may be done in slack periods and left undone in busy periods. If, after all these devices have been tried, the flow of work is still irregular, it may be necessary to apply the standards only to long periods, such as a month.

Leveling and speed rating. As previously indicated, the times actually recorded are adjusted by the observer to reflect variations from normal. In every case management must determine the level of performance to which such adjustments are to be made. In some applications, "normal" is defined as that level of performance at which an employee is considered to have earned his guaranteed base rate. In others, normal performance is that performance which is expected of the average worker under incentive. In the technique known as leveling, an attempt is made to rate the effort, skill, and consistency of the operator, and the conditions under which he works. A rating scale is used, with different degrees and values associated with predetermined descriptions. The values for the four items are then combined to obtain the leveling factor.

The leveling factor may be developed for individual element times separately, or for the cycle as a whole. The selected times are adjusted by multiplying them by the leveling factor. Assuming that the selected cycle time is 32.40 minutes and that the leveling factor is .90, the adjusted cycle time would be 32.40 × .90 or 29.16 minutes. If, on the other hand, a better-than-normal performance had been observed and the leveling factor had been 1.10, the actual cycle time would have been increased by multiplying 32.40 by 1.10 to yield a selected cycle time of 35.64 minutes. In speed rating, an attempt is made to rate only one factor, the pace of the operator. The normal pace is considered to be 60 (derived from 60 minutes of work per hour), and operators are rated in relation to that figure. Thus a 75 rating means that the operator studied was working at a pace 25 per cent above normal. Actual times taken are adjusted, under this method, by multiplying them by the factor obtained from the relationship of the operator's rating to 60. In other words, if an operator's pace is rated at 75, his actual times would be multiplied by 75/60 or 1.25 to obtain adjusted selected times. A still simpler method is to call the normal pace 100 per cent, and to express the rating of performance in percentage.

That part of time-study technique that is most criticized is the highly subjective nature of the leveling process.

Allowances. The taking of observations for the allowances presents a somewhat different problem, because it is much more difficult to obtain a satisfactory sample. If the observer is timing actual work as it goes through the shop, the set-up of a particular job will be made only once, and it is therefore more difficult to secure enough dependable data. Moreover, set-up time tends to vary because of unexpected difficulties. In the determination of unavoidable delays, the analyst may have to take observations over a long period, since such delays tend to disappear entirely and then suddenly prove bothersome again because of some change in the material or working conditions. Allowances for fatigue and personal delays present similar difficulties, because observations should be taken when the operator is tired as well as when he is rested. In general, the study of delays requires a much longer period than the study of short, repetitive operations. The most reliable method of segregating the unavoidable delays is for the observer to detect and record the cause at the time the delay is happening. This permits him to make further inquiry as to whether or not delays of a certain type can be prevented.

In allowing for fatigue, the usual method unfortunately is to add an arbitrary percentage. Perhaps the most practical method of ascertaining the *correct* percentage is by the use of a production study, which is described elsewhere. It must not be forgotten, however, that the rate of output of an employee is determined by many causes other than his fatigue. Moreover, fatigue may affect the nervous system as well as the muscles, and work that is highly fatiguing to one person may bother another person very little.

The allowances for unavoidable delays are computed by taking the average of the times recorded for each type of delay, after the delays have been classified by causes. Obviously, no allowance should be permitted for delays that can be avoided either by the workmen or by improvements in management. The delay and fatigue allowances are usually determined as percentages, which are then applied to the selected operation time referred to previously.

The treatment of the set-up time is a distinct problem. After this has been determined, there are three methods of handling it:

> A separate time is established for the setting up and tearing down of a typical job.
>
> If the variation in the size of orders is not great, a typical size is determined, and from it the preparation time per piece is computed.
>
> If the breakdown time is very small, the time for the first piece, including the set-up time, is established. Then a separate rate is figured for all additional pieces.

Analysis of data and computation of results. Time-study men use many methods in selecting the standard time for each element. Some select the arithmetic average; some select the mode (which is the most frequently recurring time for a given element); and others select the "good" time according to their own judgment. Perhaps the most satisfactory method is either the arithmetic average or the median. The latter proves very effective under a wide range of conditions, provided it is selected from a large enough number of element times. The median is merely the middle item of the series after the times for a given element have been arranged in sequence from the lowest to the highest.

After the standard element times have been selected, the selected time for the entire job cycle is secured by simple addition. As previously indicated, the actual times recorded are adjusted to "normal" by applying an adjustment factor either to each of the element times before addition or to the cycle time after addition.

Operation: Post Billing
Product Name: Accounts Receivable Ledger
Machine: Burroughs
Department: Bookkeeping
Operator's Name: Mrs. Dinger
Time Spent on Investigation & Study: From 9 A.M. to 11 A.M.

Note:
The figures below are the time-study data for a bookkeeping operation, showing the method of recording the reading. Analyze the figures and determine the task standard.

Operation Elements	1	2	3	4	5	6	7	8	9	10	*Median*
Put away & pull sheet	.04	.49	.76	1.31	1.62	1.95	2.46	2.81	3.25	3.53	
	.04	.11	.05	.12	.04	.09	.14	11	09	.07	
Locate sheet in machine	.10	.54	.82	1.35	1.66	2.01	2 52	2.87	3 30	3 59	
	.06	.05	.06	.04	.04	.06	.06	.06	.05	.06	
Make posting	.38	.71	1.19	1.58	1.86	2.32	2.70	3.16	3.46	4.00	
	.28	.17	.37	.23	.20	.31	.18	.29	.16	.41	
Put away & pull sheet	4.14	4.65	4.97	6.45	6.91	7.29	7.68	8.04	8.55	9.19	
	.14	.12	.06	.05	.11	.14	.12	.08	.22	29	
Locate sheet in machine	4.20	4.70	5.02	6.51	6.97	7.34	7.72	8.10	8.61	9.29	
	.06	.05	.05	.06	.06	.05	.04	06	.06	.10	
Make posting	4.53	4.91	5.22	6.80	7.15	7.56	7.96	8.33	8 90	9 58	
	.33	.21	.20	.29	.18	.22	.24	.23	29	29	
Delay			6.40[A] 1.18								
Put away & pull sheet	9.72	10.26	10.72	13.03	13.50	13.79	14.23	14.73	15.25	15.60	
	.14	.16	.17	.08	.23	.04	.15	.26	.20	.12	
Locate sheet in machine	9.77	10.31	10.78	13.09	13.55	13.84	14.28	14.79	15 30	15 65	
	.05	.05	.06	.06	.05	05	.05	06	.05	.05	
Make posting	10.10	10.55	11.00	13.27	13.75	14.08	14.47	15.05	15.48	15.87	
	.33	.24	.22	.18	.20	.24	.19	26	18	22	
Delay			12.95[B] 1.95								

[A] Time to prepare new ledger sheet.
[B] Time to prepare new journal sheet.

Figure 15. Time Study Observation Sheet.

Allowances for fatigue, personal needs, and unavoidable delays must be added to the adjusted cycle time for a job.[9]

Problem in Computing Selected Operation Time

On the time-study sheet (Figure 15) the stop-watch times observed on a clerical operation are entered. The operation was divided into three groups of elements, for each of which thirty times are shown. Since the watch ran continuously, the recorded times start at 0 and end at 15.87 minutes. Under each of the times recorded by the observer are indicated the elapsed times (that is, the difference between the time recorded at the end of that particular group of elements and that of the preceding group). For example, the first observation of the first group ended at .04 minutes and began at 0, so that the elapsed time was .04 minutes; the time recorded at the end of the second group was .10 minutes, so that the elapsed time was .06 minutes.

For each group of elements, compute the median time for the thirty observations applying to that group. In addition, determine which of the three groups of elements has the most consistent times. To answer this part of the question, determine which group of times shows the most concentration around the median. A convenient measure of the concentration is to find the range covered by the middle half of the items.

Recapitulation of steps in elementary time studies. The major steps involved in making time studies may be outlined as follows:

1. Analyzing the process, and/or operation, and/or job.

2. Standardizing all the working conditions involved in the operation or job. Standardization carries out or makes the changes arrived at by analysis. It aims also to make operations alike and to reduce the number of materials, tools, jigs, and fixtures. This includes the reduction of designs in order to secure longer runs on a given operation.

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[9] Assuming that the operator tends the machine 100 per cent of the time and that the total of the selected times of the various groups of elements equals the selected operation time:

Selected Operation Time	32.40 minutes
Personal Allowance, 3 per cent / Delay Allowance, 22 per cent	8.10 minutes
Task Time	40.50 minutes

3. Observing and recording the times for each element, or group of elements, and for each type of delay.

4. Computation of results in order to determine the selected time for each element and for the operation, and to determine the proper allowances for unavoidable delays and fatigue.

5. The determination of the task, or time allowance, for each *job*.

6. Where the same operation is performed on a variety of products, the construction of formulae or tables of basic times from which the task for any job can be estimated. This step requires that the original data be taken for fundamental elements; that the data be classified after dividing the elements into constants and variables; that the constant times be selected; and that the variables be expressed in graphs in order to show the relationship of time to the other variables (such as the thickness of plate, the diameter of holes, or the weight).

Use of basic data. If a company has tables of basic data, an experienced man can estimate from them the task time for doing any operation on any given job. This process converts the problem from one of constantly making time studies in the shop to one of estimating in the office. Provided the conditions for which the standard times are set are maintained at standard, a skilled estimator can set uniform and satisfactory task times. In Table 2 and Figure 16 is presented an example of how basic data for bench molding in a foundry can be utilized to estimate the standard time for a particular job, the making of a cast-iron flywheel. The table of basic times was compiled from time studies of many separate jobs and therefore represents a recapitulation. From it, someone thoroughly acquainted with the operation of this particular foundry could estimate the time for any product, such as this flywheel, before its production began. Such estimates are

TABLE 2

BASIC TIMES FOR BENCH MOLDING

Foundry Department

Operation: Regular Bench Molding	*Man-Hours*
Filling flask, etc. per cubic foot in flask	.0540
Constant time per flask of	.0266
Set patterns—each	.0008
Parting rate*:	
Rate 1	.0010
Rate 2	.0025
Rate 3	.0038
Rate 4	.0125
Rate 5	.0266
Set gates—after first is set, each	.0005
Sponge patterns—each	.0018
Rap and draw patterns—each	.0038
Dressing time*:	
Simple	.0056
Medium	.0167
Maximum	.0418
Set cores:	
Set one large core	.0067
Set one small core	.0012
Rub and set one core	.0032
Set and nail one core	.0031
Rub, set, and nail one core	.0052
Rub, set, and vent one core	.0037
Rub, set, vent, and nail one core	.0057
Punch hole, rub, and set one core	.0043
Punch hole, rub, set, and vent one core	.0048
Standard Extras:	
Set split patterns—each pair	.0168
Check work—for each square foot	.0500
Set gaggers or soldiers—each	.0014
Set nails—each	.0008
Allowance—.26 of total time	

* The diagrams indicating which rate to use are omitted.

needed not only for quoting prices to customers, but also for rate setting.

Production time-studies. To make a production time study for the determination of delay allowances, the observer allows his watch to run continuously for the duration of the study and notes interruptions in the operation. (See Figure 17.) After the data are recorded he summarizes them as to the causes of delay, as shown in Figure 18. These delays are

ESTIMATE SHEET

FOR MOLDING CAST-IRON FLYWHEEL

DATA:

TYPE OF MOLDING–
REGULAR BENCH MOLDING.

PIECE TO BE MADE–
CAST-IRON FLYWHEEL.

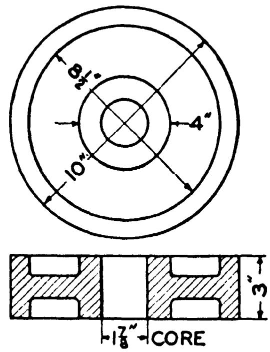
CUBIC CONTENTS–145.93 CU. IN.

WEIGHT OF ONE CU. FT. OF
CAST IRON–480 LBS.

WEIGHT OF CASTING–41 LBS.

SIZE OF FLASK (SNAP):
16″X 16″X 8″.

CUBIC CONTENT OF FLASK–
1.185 CU. FT.



MOLDING TIME

	MAN HOURS
MULTIPLY CUBIC CONTENTS OF FLASK BY 0.0540 MAN HOURS.	0.0640
ADD CONSTANT FACTOR TO COVER ELEMENTS IDENTICAL FOR ALL JOBS.	0.0266
SET PATTERN (TWO)	0.0016
PARTING RATE (RATE 1)	0.0010
SET EXTRA GATES (TWO) .0005 EACH	0.0010
SPONGE PATTERNS (TWO) .0018 EACH	0.0036
RAP AND DRAW PATTERNS (TWO) .0038 EACH	0.0076
ADD DRESSING TIME (MAXIMUM RATE)	0.0418
ADD CORE TIME (RUB, SET, VENT AND NAIL CORE)	0.0057
ADD STANDARD EXTRAS–TO SET SPLIT PATTERN.	0.0168
MAN HRS.	0.1697
ALLOWANCE .26 OF TOTAL TIME. MAN HRS.	0.2138

Figure 16.

analyzed to determine which of them are avoidable and which are unavoidable. The percentage of delay allowance is determined by dividing the unavoidable delay time by the total time observed minus the time consumed by delays, both avoidable and unavoidable.

Situations presenting special problems. To develop task times for *automatic machines,* determine the theoretical capacity of the machine and then reduce it to an attainable task level by applying the delay allowances. An automatic screw machine, a loom, and a paper-bag machine would all require such a technique.

When work is of a *heterogeneous nature* (that is, when operations are similar but not identical and not on a conveyor), it is sometimes quite difficult to measure all of the

PRODUCTION STUDY
OBSERVATION SHEET

TEST NO. 1 SHEET NO. 1 LOOM NO. 47
OCT. 5, 1931 OBSERVER-C.N.UNDERWOOD

TIME			REMARKS
FROM	TO	ELAPSED	
0	4.90	4.90	WEAVER LATE
4.90	6.30	1.40	OIL
6.30	8.00	1.70	INTERFERENCE
8.00	10.18	2.18	WEAVE
10.18	10.65	.47	FINDING PICK
10.65	14.49	3.84	WEAVE
4.49	14.57	.08	CHANGE SHUTTLE
14.57	21.07	6.50	WEAVE
21.07	24.42	3.35	FINDING PICK
24.42	24.46	.04	WEAVE
24.46	24.80	.34	START AND STOP MACHINE
24.80	25.00	.20	WEAVE
25.00	30.30	5.30	FINDING PICK

Figure 17.

work done in terms of a single unit. For example, Elliott-Fisher operators and other clerical workers may perform the same operation upon several lines of work that vary in difficulty. To use a simple unit in such a case, such as the "item," it is necessary to make a statistical study to discover what percentage of the total tends to fall in each category of difficulty. If such a study covers a sufficient period of time to determine the day-to-day variation in the mixture of the work, then it may be possible to use the percentage that appears to fall in a given class as a means of weighting the time required to do the work in that class. In short, a single unit may be employed by time-studying each class of work and combining the

PRODUCTION STUDY

OF TWO SHAFT LOOMS MAKING LIGHT-WEIGHT CLOTH

OPERATOR
OPERATING-2 SHAFT LOOMS
OBSERVER-C.N.UNDERWOOD.

	SYMBOL	CAUSE	10-5-31		10-6-31		10-7-31		10-8-31		TOTAL	
			NO.47	NO.48	NO.47	NO.48	NO.47	NO.48	NO.47	NO.48	NO.47	NO.48
UNAVOIDABLE DELAYS	A	LOOM OPERATING TIME	348.50	337.92	390.22	373.38	400.44	389.33	384.12	362.51	1523.28	1463.14
	B	CHANGE SHUTTLE	8.72	1.28	8.11	7.31	7.11	7.47	6.41	8.12	30.36	34.18
	C	OIL MACHINE	2.26	224	.99	2.54	2.37	2.35	1.22	1.80	6.84	8.93
	D	INTERFERENCE	9.83	14.81	5.99	2.64	2.51	4.03	5.09	2.50	23.42	23.98
	E	BROKEN FILLING	24.47	11.73		6.80	4.78	6.77	2.04	6.07	31.29	31.37
	F	BROKEN WARP	2.29	6.55				8.36		16.20	2.29	31.11
	G	REPLACE BAD BOBBIN			.43	2.49	.37	63			.80	3.12
	H	RIP OUT FILLING	5.43	5.59							9.58	5.59
	J	LOOM SLIPPED OFF	.28	.57	.59		1.18	.46			2.05	1.03
	K	BOBBIN RAN OUT		.51			1.28	66	1.42	4.28	2.70	5.45
	L	REMOVE FINISHED PIECE			5.91	4.80				6.08	5.91	10.88
	M	REPAIR LOOM		2.69		12.98			10.42		10.42	15.67
	N	PUT IN NEW SELVAGE SPOOL		5.84							.00	5.84
	P	ADJUST MACHINE	.62	74	79	.61			.27	3.19	1.68	4.54
	Q	PERSONAL								.27	.00	.27
	R	MISCELLANEOUS		1.52							.00	1.52
	S	GET FILLING	21.05	21.41	15.52	15.11	9.08	9.04	10.18	10.23	51.68	55.79
	T	LATE START	4.90	4.90	2.35	2.35	1.57	1.57	3.85	3.85	12.67	12.67
	U	EARLY START	6.65	6.70	4.10	3.99	4.30	4.33	9.98	9.90	25.03	24.92
		TOTAL	435.00	435.00	435.00	435.00	435.00	435.00	435.00	435.00	1740.00	1740.00
	W	WEAVERS OPERATING TIME	65.12	62.14	32.34	39.66	26.18	35.74	21.54	55.97	145.18	193.51

Figure 18.

results by weighting each class according to the distribution of work determined statistically.

Take, for example, a billing operation in a certain company in which different forms were used in each of its three plants. Those for one plant required 7.77 copies, on the average; for another, 2.7 copies; for a third, 3.06 copies. Again, the number of items appearing on the bills varied in the different plants. For one, the average was 13.18 items; for another, 9.88; and for a third, 13.0 items. These data were needed to compute the standard time per bill, which was 14.17 minutes, 13.08 minutes, and 13.87 minutes, respectively.

In setting *group tasks,* it is especially important to select with care the units of work in which the tasks are to be assigned and for which the actual output is to be measured. Since the unit selected should reflect the effort and the time expended, the problem must be approached by determining the real nature of the work done. On an assembly line, for example, the unit selected will be either a sub-assembly or a completed product. However, for indirect labor, such as that used in receiving, shipping, and trucking operations, the selection of a unit is more difficult. For example, in a storeroom the time required for some work varies with the number of pieces, and for other work, with the weight to be handled. In addition to reflecting the effort put forth, the unit should be definite and objective. Everyone understands what is meant by feet, pounds, and number of items, but such terms as "cleanliness" permit of many interpretations.

An unusual problem in setting group tasks is that encountered when work is already done on a *conveyor.* In such an instance, it is difficult to determine, except by trial and error, the ideal balance of jobs along the conveyor. Since the speed of the conveyor controls the flow of work to each individual along the line, it is difficult for the observer to estimate time lost from lack of balance in the jobs. The solution is less difficult if the analyst has the opportunity to time the operations before they are placed on a conveyor so that the most effective combination of jobs can be determined from the time studies.

If the group has been working on the conveyor for some time, however, the observer has two alternatives, neither of which is wholly satisfactory. One is to accept the existing arrangement of jobs as the best obtainable, and then to time the individual who has the most work to perform (that is, whose operation takes longest). Another is the empirical method of experimenting with the speed of the belt and with the combination of duties into jobs until the largest output has been secured. Then a production time study will reveal the amount of delay allowance which should be added. *It is often found necessary to determine a series of such allowances because the changing of the mixture of products or of the volume of production affects the balance.*[10]

Limits of time study. It is important to point out that the results of a time study are only approximate and are affected by the analytical ability of the observer. Moreover, the usefulness of the result depends greatly upon the ability of the management to control the conditions affecting the work in order to maintain them at standard. A time-studied task is really a prediction which is only reliable to the extent that the variables affecting output can be kept stable.

That Taylor was under no illusions on this point is brought out forcibly by Copley.

> It would appear also that some people think that when you speak of the scientific, you necessarily are referring to something of hair-line accuracy. Thus when it was brought out in investigations of the workings of time study that, in recording such things as the "percentage which must be added to the actual working time of a good workman to cover unavoidable delays," one must depend largely on common sense, there were not lacking those who declared that that showed up the whole thing

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[10] C. C. Balderston, *Group Incentives,* page 43. Philadelphia: University of Pennsylvania Press, 1930.

> as unscientific. Taylor, of course, never dreamed of asserting that there was anything exact about time study in the sense that the sciences of mathematics and music are exact. "The whole subject of time study," he told the Special House Committee, "is only an approximation. There is nothing positively accurate about time study from end to end. All we hope to do through time study is to get a vastly closer approximation as to time than we ever had before." [11]

It is ridiculous to assume that rates established for a given set of conditions will remain correct indefinitely. Therefore a means must be developed for informing the standards department of changes in method as soon as they occur. Swift and Company, meat-packing house, has adopted a double check to keep its labor standards up-to-date. Changes in operations are reported both by the foremen and by checkers representing the standards department. Since the changes may be as numerous as one hundred a week, the two sources of information are important. Other companies use a method less easily defended, which is to inspect the earnings of workers on incentive, and to check up on the standards in cases of earnings higher or lower than the average.

Questions:

1. How completely should the job be described on the time-study observation sheet?

2. What practical considerations should be taken into account in grouping the elements for timing?

3. Outline the factors influencing the size of sample necessary to establish valid times for:

(a) A repetitive motion cycle.

(b) Delay allowances.

4. How may time-study men be trained to level or speed-rate uniformly?

5. What parts of time study are most susceptible to an attack on the weaknesses inherent in the method?

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[11] F. B. Copley, *Frederick W. Taylor,* page 234. New York: Harper and Brothers, 1923.

6. Should time studies be made secretly? Should management disclose to workers the details of a particular time study? In a unionized shop, should the time-study methods be subjected to joint discussion and agreements?

Section IV

DESIGN AND INSPECTION OF PRODUCT

CHAPTER 11

Product Design

To maintain or improve its competitive position a company needs products that are equal to or superior to those of competitors. There is no finality in product development. A dynamic industry is constantly changing, and a company, if it is to survive, must be attuned to these changes. To succeed in the struggle for survival, companies must impart to their products the quality of uniqueness—those characteristics that make them different. A company must keep its products attuned to changes in consumer interest.

Field of product design. The term "product design," considered broadly, includes the whole development of the product from the birth of the original idea until the product can be made and marketed successfully. In the narrow sense, it is the determination, in advance, of what the article will be like when it is finished. This includes the decision as to the composition and structure of the product, which will be reflected in artists' conceptions and in the engineering drawings and models.

The field of product design may be classified into four major divisions:

1. Design of new products
   (a) in the same line.
   (b) in supplementary lines.
2. Redesign of existing products
   (a) for wider use.
   (b) for economic production.
   (c) for greater consumer appeal.

3. Development of new uses for existing products.
4. Improvements in packaging
   (a) for greater sales appeal to consumer.
   (b) for greater convenience in using.
   (c) for more saleable sizes.

Methods of securing new products. In its search for new products a company may adopt any one or a combination of the following methods: purchase of a company or of an invention; piracy; licensing; and product research within the company.

New products may be acquired by absorbing companies with successful products. This method is useful to obtain a line of product that is entirely different. A going plant brings with it manufacturing facilities, personnel with "know how," a known trade name, and a marketing organization. Such a policy has been followed by the American Home Products, Nash-Kelvinator, Kendall Mills, General Mills, and General Motors companies. Or a company may buy an invention, and with the invention may acquire the services of the inventor himself.

In contrast, a ruthless method is to pirate a new design by stealing or copying the designs of others. The textile and clothing industries have been plagued by this practice, because a similar over-all effect is obtainable by a slight change of the original design. In a style center, like New York, it is not unusual to see designers standing in front of store windows sketching the design of a particular dress, hat or pattern of cloth. Such piracy is to be distinguished from the imitation of general ideas such as floating soaps or automobile body design.

The policy of licensing has been used by the automobile, radio, aircraft, chemical, and steel industries. The licensee resorts to payments to owners of basic patents in order to have the right to incorporate the protected idea in the manufacture of his own product. In this way he can broaden his product line without the risk of infringement.

By far the most significant method of developing new products is the organized research departments as in chemical, petroleum, and electrical companies. Among the outstanding examples are Bell Laboratories, R.C.A., Eastman Kodak, Dow Chemical, Gulf Oil, and General Electric. Although the detailed activities of such departments vary among companies, they all perform the same basic function, which is to originate new products and processes. In general the heads of these departments hold top executive positions, and as vice-presidents, report to the president directly.

The practice of the DuPont Company illustrates the activities of a highly developed research program. The activities are divided into three broad classifications:

1. Improvement of existing processes and products.
2. Development of new products.
3. Fundamental research.

The first is a never-ending search, important because of the DuPont policy of selling at lower and lower prices in order to enlarge sales volume. Successive reductions in the prices of nylon and cellophane, made possible by technical research, expanded their markets tremendously.

The significance of the second activity is shown by the fact that, in 1947, products introduced or substantially developed since 1928 accounted for 58 per cent of DuPont sales. The improvement of existing processes and products and the development of new products are applied research, in that existing knowledge is brought to bear on the solution of immediate problems.

Fundamental research is conducted by DuPont to advance the frontiers of theoretical knowledge without concern for immediate commercial application. It is, however, supported with the hope of ultimate usefulness. For instance, nylon and ethyl gasoline are the result of both fundamental and applied research.

The organization of product research. Product research may be organized in different ways. One is a completely centralized unit for the company as a whole. This concentrates control in one group of competent technicians. Another is to decentralize the control by associating the research staff with that part of the organization that is responsible for a given line of product. This method is usually combined with a central group devoted to such fundamental research as the company may undertake. The central group may also coordinate the work of the separate units. A third type of organization is found in small companies that make operating executives responsible for product design.

Within the research department the organization pattern may take either of two basic forms: the assignment of responsibility by a product project, such as a new aircraft model; or by a basic research function, such as aerodynamics or stress analysis. In the former, each project is directed by a supervisor to whom the necessary specialists are assigned. Unless the project is large and long-continuing, the specialists must be moved from supervisor to supervisor too frequently. In the second a supervisor directs a group of specialists in a given field who work on *all* products. Such an organization lacks the coordination of the previous type, but it is more permanent. A compromise is to superimpose a group of product coordinators.

Because the results achieved from research depend greatly upon ability, many research directors feel that one good man is worth ten mediocre ones. Those rare individuals with creative ability are assigned an ample number of technical assistants and are relieved of management chores by administrative assistants who work with them. For example, in the DuPont Company a research team may be composed of the project head, an administrative aide and twenty-five or more technical assistants.

Variations in the life cycles of product. Management is interested in the length and shape of the life cycle of its products. The longer the development period the greater must be the financial resources because of the long interval before the product is sold on a profitable basis. In contrast, if the development period is short, it is necessary, as in style industries, to time the introduction of new models in order to "hit the market." The shorter the cycle, the more important research is in developing new products to replace those that die. Investment in special-purpose machines and tools will depend on its recovery during the life of the product. Finally, products subject to a rapid decline and demise expose a company to inventory losses.

The life cycle of products varies widely from product to product. For example, in the style branches of the textile industry the life span may be measured in months, for engineering specialties in years, and for staples, like salt, in decades. "King Tut" fashions were the rage for a season and then yielded to another fashion. In the case of chemical products and engineering specialties, fifteen or twenty years may be needed for a particular design to mature. The principle of television was known twenty years at least before the large scale production of sets. The research that led to DuPont's neoprene began in 1926, but manufacturing did not start until 1932, and it was not until the end of 1937 that the selling price exceeded costs. As volume increased, costs and prices were reduced progressively. DuPont's dye business operated six years before making a profit, and during this period the total expenditures exceeded $40,000,000.

From laboratory to full-scale manufacture. The shift from laboratory production to full-scale manufacturing is financially hazardous if it is done too quickly. Physical and chemical reactions, secured easily and controlled in the laboratory, may prove unworkable in the full-sized commercial plant. To reduce the risk of loss, chemical engineers increase the scale of production gradually. For example, Standard Oil Company of Indiana uncovered the new problems associated with a threefold increase of pressure in the Burton process by using successively a 1-quart bomb, a 13 gallon still, a 50 gallon still, a plant of 8,500 gallon capacity, and finally multiples of such plants.

An idea of the gradual evolution needed for chemical projects can be gained from the five stages used in the development of the Whiting electrolytic cell.[1] They are:

1. The laboratory stage to test the fundamental technical principles.
2. Small-sized model to determine the optimum operating conditions.
3. Large-sized unit to provide a practical test for the design.
4. Semi-commercial plant to produce enough product to test its quality in actual use, to secure cost data, and to determine the labor skill required.
5. Full-sized commercial plant.

Design factors. The designer should never lose sight of the fact that the product is being designed for the consumer. What he desires and will buy is the test of whether the designing is effective. Few companies bring out a new product before securing factual data from market research to determine its acceptability. Yet occasionally companies fail to take this precaution. A radio equipment maker lost over a million dollars in a year on one of its products because it failed to make a proper study of the market.

The present-day consumer not only wants utility at a price, but attractiveness. Recognizing this fact, companies utilize industrial designers to restyle their lines. For example, Norman Bel Geddes has designed products for the Simmons Company; Walter Teague, for the General Register and the Taylor Instrument companies; Edmund Ashe for the Wear-

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[1] Chaplin Tyler, *Chemical Engineering Economics*, pages 32 and 33. McGraw-Hill Book Company, Inc., New York, 1938.

ever Company; and Edwin Fuerst for the Parker Pen Company.

The influence of artists and the growing demand for color harmony have increased the use of color in industrial products. Production machinery, for many years available only in black or gray, is now obtainable in many pastel shades. Even without any change in design, color adds to the attractiveness of a product, but, when combined with artistic functional design, it adds to product success.

In recent years the designer has had at his disposal a larger variety of materials and processes to aid him in making products distinctive. Plastics, alloy steels, aluminum, magnesium, plywood, pressed wood, and fiber have given him greater versatility in this respect as have processes like die casting, more versatile metal stamping, moulding of powdered metals, welding, and paint spraying. The more he knows about manufacturing methods the more practical his designs will be. In some plants the determination of the processes to be used is performed by process engineers who cooperate with the designer to create designs that can be made at low cost. Interchangeability of parts has made possible our mass production of highly standardized articles, such as radios and automobiles, and in addition has decreased the cost of repairing them. Newly designed products should incorporate as many parts as possible that are already used in other models.

Moreover, the products developed should utilize the existing production facilities of the organization as well as its skills, both managerial and technical. If the existing products are of high quality, the introduction of one of lower quality may reduce the quality standards of all.

Furthermore, if the product cannot be sold by the present sales force, a separate selling organization may be required. For example, a company manufacturing automobile accessories will have no great difficulty distributing another product in the same line; on the other hand, should such a company introduce an electrical refrigerator, a new selling organization must be developed and the company is confronted with unfamiliar problems in an entirely different field. Companies have frequently developed good products in lines other than their own only to find out, too late, that competitive conditions were so severe as to prevent their breaking into the established market without excessive expenditures on advertising, sales promotion, and the building of a sales organization.

Management problems of product development. Management problems arising in connection with the design of a product have principally to do with:

1. The speed with which new products can be placed upon the market, and the need for coordinating the various departments dealing with design.
2. The appropriation of funds for research.
3. The control of research.
4. The effect of the introduction of a new product upon the rest of the company's line.

Speed and coordination. An important factor in the successful handling of new or improved products is the speed with which they can be introduced into the market. A company that is the first to bring out a successful product or style has a distinct advantage over its competitors. A tardy company will usually find that its prompt competitor has obtained the easiest and most profitable business. In style industries, such as women's wear, the companies enjoying prosperous seasons are those that have successful lines at their "openings."

In order that a company may bring out new products in the shortest time possible, it must be organized to act quickly in meeting the demands of the market. Not only must executives in charge of designing, purchasing, production, and selling, work in harmony, but someone must have sufficient authority to secure decisions promptly so that production may be started without delay. Many large organizations with huge engineering, sales, and manufacturing staffs move slowly because their procedures are cumbersome. The approval of ideas and responses to suggestions may be bound up with red tape. In the small organization, however, fewer persons need to be consulted, and discussion replaces elaborate reports and routines. A small air-compressor company brought out a new product months before large competitors and thus obtained a temporary advantage. To improve the speed of coordination, some large companies have organized on a product basis. Examples are General Electric, RCA Victor Division of RCA, and Westinghouse, in which a product division head, controlling all the activities necessary for the engineering, tooling, and manufacturing of his particular product, can readily coordinate his departments.

Speed, however important, must not be secured at the sacrifice of good designing and adequate market analysis. It is cheaper to change a product on the drawing board than after production has started or sales have been made. Some automobile companies have put out a new model only to find that the early cars of that model require the adjustment or the replacement of parts, with resultant injury to their reputation.

Research appropriations. It is essential that the work and expense of a product research department be controlled if such a department is to yield the maximum return. Some companies relate the funds made available for product research to gross business; they may appropriate to it from 1½ to over 5 per cent of sales income. The weakness of this automatic method is that it treats research expense as a variable without regard to the essential long-run need for new products. A period of declining sales may be the very time when product development should be accelerated. The decimation of research staffs to gain a temporary economy forces a subsequent rebuilding of the research program and the deferment of the introduction of new products.

In this respect, large companies have an advantage over smaller ones because of their capital resources. These companies tend to look upon research as growth insurance. Consequently their appropriations are based, not on sales income, but on the estimated value of their long-time research.

This amount must be allocated to specific projects on the basis of probable return. The selection of the particular project likely to benefit the company most is usually decided by a committee composed of the director of research and the heads of major departments.

Still another approach is to base appropriations on the appraisal of the value of individual projects regardless of the time during the budget period when the projects are proposed. This might be termed the *ad hoc* method.

Control of research costs. Some companies keep costs on each project in order to compare them with the amount budgeted at the time the project was approved. Ordinarily the budget must be adhered to, or if it is exceeded there must be adequate justification for an additional appropriation. Other companies keep costs only in broad terms, and charge off all development expense at the end of the year as an expense.

Closeness of cost control is a function of the time at which research bears fruit. The work of a drafting room is frequently to modify existing designs to meet the peculiar needs of customers. It is easy to account for the costs of such alterations. Applied research comes to fruition less quickly but its costs can be segregated by projects because the latter are definite; moreover, its commercial value can be estimated, at least roughly. In the case of fundamental research, however, top management must rely on its faith, bolstered perhaps by experience, that expenditures will justify themselves in the long run through discoveries or inventions whose specific nature is unpredictable. In the control of such expenditures, management must rely therefore upon the technical skill and judgment of a research administrator such as Charles F. Kettering, of General Motors.

Effects of new products. A new product may diminish the sales of more profitable existing ones, and thus increase competition among the company's own lines. Moreover, the new product may make existing ones obsolete. Or, the addition of the new product may create production and servicing difficulties of the type discussed in connection with product simplification.

Patents. Without the patent laws, which have encouraged the investment of millions of dollars in research and product development, there would be little assurance that these expenditures would be recovered. Those responsible for product development must be alert to avoid infringement on the patents of others with resultant litigation and damages.

Product design—Buick Motor Company. In the Buick Company, the general procedure and the departments involved in the design of a new model are as follows:

The Art and Color Department has charge of body style and color, both interior and exterior. First, small clay models are made from which the general style is determined. Next, a full-sized model is built by using wood frame and lath construction, covered with clay which can be moulded to the final shape. When the design has been approved the model is painted. Next, a mahogany model is made which is an exact reproduction of the full-sized wood and clay model. It is painted, trimmed with hardware, and upholstered. This serves as a permanent standard for measurement. Later, when production has been begun, random cars off the assembly line are checked against this standard model.

General Motors Research Department is engaged continuously in mechanical developments. *New Devices* is a division of research that handles the correspondence and testing concerning all ideas that originate outside of the General Motors organization. Less than 1 per cent of such ideas submitted have proven to be usable.

The chief engineer approves the general body design and the task of preparing detailed specifications is assigned to the division engineers. The work is divided into the following six groups: (1) engine; (2) chassis (frame, wheels, steering, springs—in general, those chassis parts involving handling and riding characteristics); (3) chassis units (clutch, brakes, axles—in general, all parts possessing dynamic characteristics); (4) electrical; (5) body; and (6) administrative (planning and coordination of other divisions). In developing the details use is made of the findings of the General Motors Research Department mentioned above. The foregoing Divisional Engineering Divisions also use the Drafting Department for the preparation of working drawings and the Technical Data and Identification Departments for cost studies.

When this work has been completed, experimental parts are made and cars assembled. The Engineering Department has complete facilities for manufacturing these experimental cars. The cars and parts are tested in the Dynamic Laboratory, by road tests on the General Motors Testing Grounds, and in the Metallurgical Laboratories. Such adjustments and changes are made as are necessary or advisable. The whole car is designed so that all parts should wear equally well. This means that parts originally made too strong or heavy are lightened and parts made too weak are strengthened. Final detailed drawings and specifications are then prepared. The car is approved for production and is turned over to the Manufacturing Standards Division. The latter prepares tools and dies and establishes operating and output standards for issuance to the sub-assembly plants at the time of the changeover to the new model.

Questions:

1. How do you explain the fact that small concerns can continue to compete with large corporations—for example, the General Electric Company—which spend large sums for research?

2. What are the risks to a company that conceives of its product development program as the mere improvement of existing lines of product?

3. Trace the impact upon other enterprises of the development of:
   (a) Television.
   (b) Diesel engines.

(c) Home hair-wave sets.

(d) Deep freeze units.

4. What steps may a company take to prepare for competition from new products?

5. What weaknesses may be encountered from an extremely simple method of approving new products introduced in order to secure speed? To overcome such weaknesses, one company adopted a procedure with 65 separate steps. Criticize this remedy.

CHAPTER 12

Simplification and Diversification

SIMPLIFICATION is the elimination of excessive variety of parts and products; diversification is the increase in their number. The choice between simplification and diversification influences both the methods of manufacturing, and the techniques of selling. In general, simplification makes production more efficient and economical, whereas diversity facilitates marketing. The real management problem, therefore, is to secure the proper balance between too much diversity for economy and too much simplification for protecting sales volume.

Simplification. The emphasis in simplifying products must be placed upon the elimination of unnecessary variety and immaterial differences. The great opportunity for simplification can be made clear by a few examples. One company, before starting upon a simplification program, manufactured 1,100 different water closets; another company, 2,000 varieties of writing paper. There were 33 different lengths, 34 different widths, and 44 different heights of hospital beds in use; 49 different types of milk bottles; 66 different varieties of paving brick; 130 sizes of range boilers; 312 different sizes and types of screws.

The virtues of simplification can best be revealed by presenting an actual case of a scale manufacturer. The scale business sickened from excessive diversity.

> Scale factories practically became job shops. For example, the Toledo Scale Company had eight platform sizes of just one type of industrial scale. There were

three sizes of heads, which were composed of the housing, the double pendulum mechanism and the chart. These three size heads with the eight platform sizes, therefore, made 24 models. There was a demand for different types of dials, which resulted in thirteen combinations of dials and beams. This again multiplied the number of this one type of industrial scale to 312. Any one of the heads could be built on the scale facing in one of four different directions, resulting in 1,248 models of just one type of industrial scale. In one of the most popular types, a portable scale, those sold in one year differed in 418 major or minor respects. Before the standardization work was begun, this company was actually producing more than 12,000 different scale models, but a check revealed that only eight per cent of these models produced 91 per cent of the unit sales.

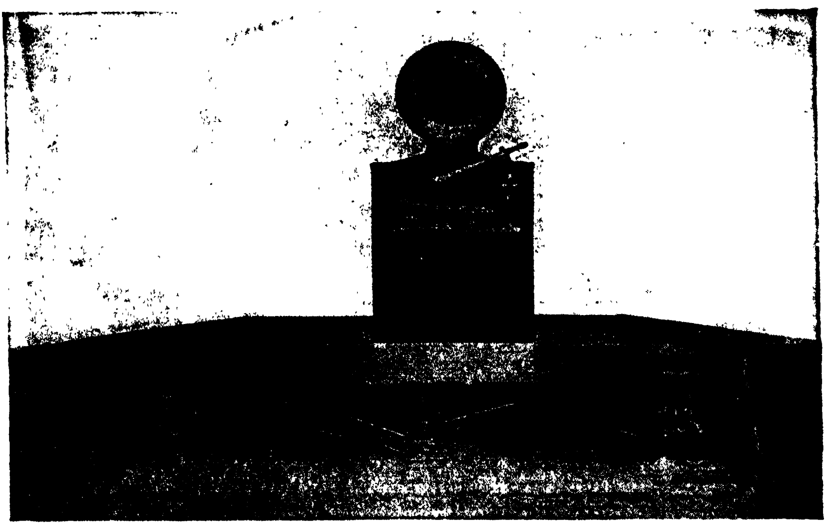

Figure 19.

Another situation which developed, parallel with the demand for a large number of different models, was the design of individual parts for each, resulting also in adding to the complexity in manufacturing and distribution. Roughly speaking, the platform mechanism of the scale is composed of the platform, levers, bearings, pivots and yokes, and in the years past, when a new model or special model was designed, the product designer designed these parts to fit the particular model under consideration and to suit his individual ideas. The result was a multiplicity of these parts. This not only meant

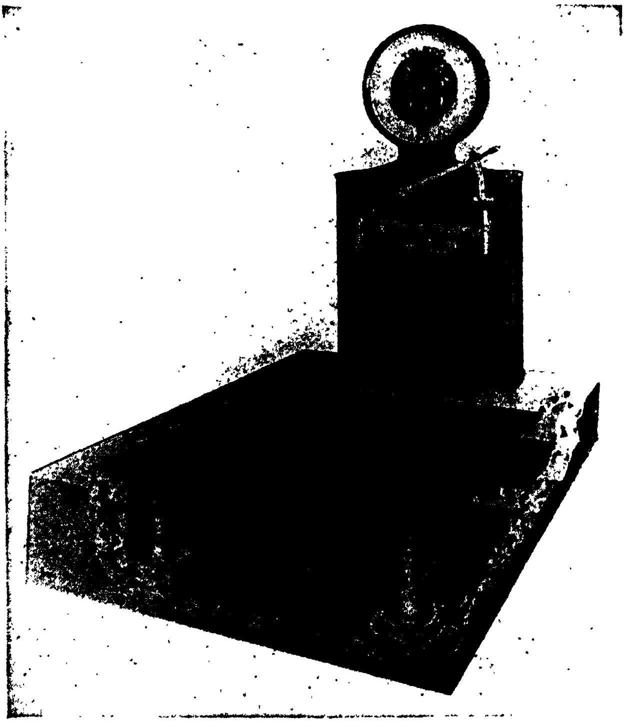

Figure 20.

an excessively large factory stock, but also a tremendous investment in parts in the 181 service stations of the company.

When the standardization program was embarked upon, someone woke up to the fact that, while a heavy capacity model could not use the smaller levers and other parts which were in the lower capacity models, there was no good reason why the lower capacity scales could not be equipped with the heavier parts of the larger models.

While, from a standpoint of material, this might add to cost, nevertheless, the tremendous savings involved in manufacture, warehousing, and distribution would offset any extra cost.

. . . As a result of this standardization program platform sizes were reduced to three. The three styles of indicating head mechanisms were standardized into a single unit. The total number of 195 dials was reduced to 13. About 1,600 of the original 2,700 parts were entirely eliminated. This necessitated the design of an additional 200 new parts which made the total of 1,320 parts now in use, or 51 per cent of the parts originally used. Service of scales has been made much easier by the standardization program. For example, it is now possible to change a complete set of pivots and bearings in the newer Toledo floor scale in from one to two hours. Formerly the job required from one to two days, and the services of a special mechanic to hone and fit the pivots and bearings. The standardization program has not only greatly reduced the number of parts carried in service branches, but it has resulted in design improvements in all scale models. The resulting savings in manufacturing costs have also enabled the company to incorporate into its product better materials and workmanship at the original, or even lower, sales cost.[1]

Development of simplification program. Any procedure for product simplification must be based upon the assumption that the production and the purchasing departments are usually in favor of it. On the other hand, the sales department often believes that the operation of the program is opposed to its interests, since variety facilitates selling. After all, customers like to be humored with special features. No one simplification program will fit all companies. In each case the procedure must take into account the factors listed below:

1. Number of items manufactured at present.
2. Past sales of each item over a period of years.
3. Future market possibilities of each item.

[1] H. W. Hem, *Product Engineering*, November, 1931, pages 494-496.

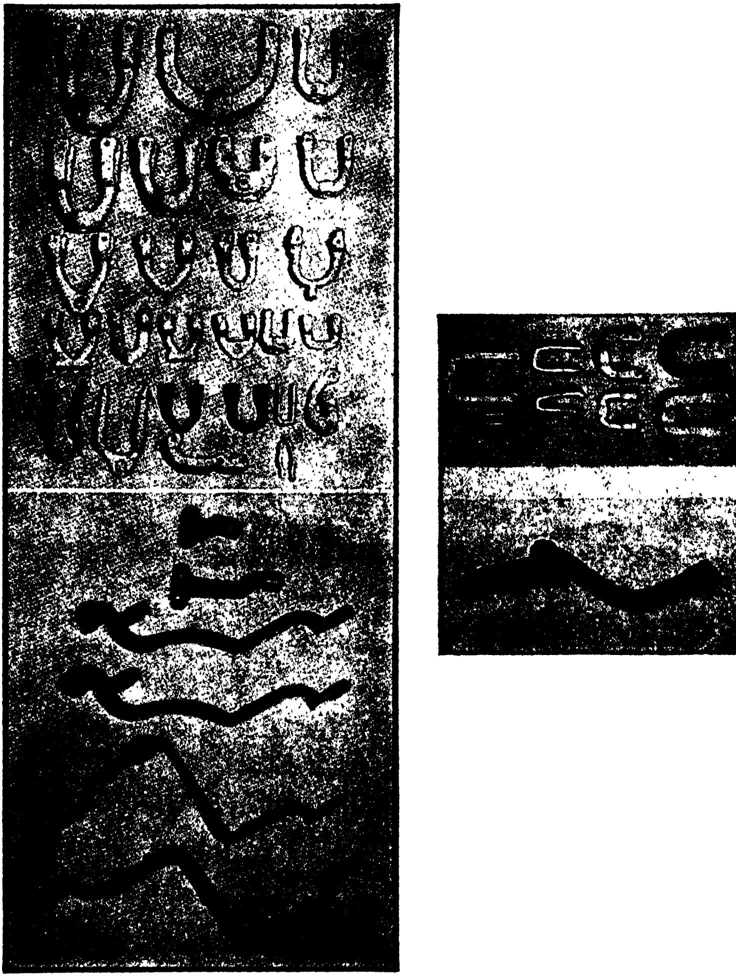

Figure 21. Standardization of Parts

4. Contribution of each design to overhead and profit.
5. Degree of standardization of parts.
6. Extent of interchangeability.

The method used by the Walworth Manufacturing Company, makers of pipes and fittings, in developing and carrying through a program of simplification is described below:

The manner in which this problem (excess variety) came to our attention was through the fact that, although we had large inventories in the aggregate, we also had huge "shortages" in many lines. Evidently, we had considerable "dead stock" on our hands. We were unable to give our customers the best service. We had large sums "frozen" in slowly moving merchandise inventories and were, consequently, losing profits.

We catalogue some 17,000 different items of our own manufacture, but a most casual glance through our Balance of Stores records indicated that there were hundreds, if not thousands, of these in the slowly moving class. We decided, therefore, to determine which were the 500 fastest moving, or most significant, items. In order to do this, we tabulated by pieces and by weight our yearly sales, in terms of orders received at the factories, for a period of five years, and determined the yearly averages over this period. We found it expedient to expand our list so as to include 610 items. What did this simple analysis reveal? It showed us, much to our surprise, that between 60 and 65 per cent of our tonnage output is represented by these 610 items. The answer was obvious. Thousands of the other items are, no doubt, very essential to the community, but there are also thousands of the other items for which standard material can be substituted. Our thought is to increase the size of our list of fast-moving items so as to embrace all items which we would stock, and to stock only the significant items. All other material would be considered as special and made on order only.

By coordinating our production with the demand for these important items so as to have them always in stock, we hope to persuade the trade to take the standard material, and receive immediate delivery, rather than to wait for a somewhat modified pattern. The coordination of our sales and production is the extremely important consideration, as this will enable us always to supply our customers; it will allow us to maintain our inventories at the minimum, giving us a maximum turnover, and tying up a minimum of investment in merchandise. . . .[2]

[2] Fabricated Production Department, Chamber of Commerce of the United States, Washington, D. C.

Even though the product is a non-style article, it is often necessary to manufacture considerable varieties of it in order to meet the needs of consumers. Where such is the case, much can be done to reduce the ill effects of variety by designing all products in such a way that standard parts can be used in their manufacture. Frequently 80 or 85 per cent of the parts can be standard, and the advantages of product standardization can, to a large extent, thus be attained. The Miller Company, manufacturers of table and floor lamps, design their products so that 46 parts will make 4,750 different lamps.

A method of obtaining variations in the final product is the use of the so-called "unit construction" in machine-tool building. In this industry machines are constructed in certain basic units or assemblies, which can be so combined that a number of variations in the final product are possible. For example, the Sunstrand Machine Tool Company produces a "Rigidmil," composed of three units, a base, a spindle head, and a table. There are two types of spindle heads, horizontal and vertical; and two types of tables, reciprocating and rotary. These units can be combined with the base to make four Rigidmils: namely, horizontal, vertical, reciprocating, and rotary. Each of these machines is complete in itself and suited for a particular type of work. If, after installation, the type of work changes and it is necessary to have a type of Rigidmil other than the one installed, it is possible to convert the existing machine into any of the other types.

In the case of many articles entering into the manufacture of products, standardization is not only desirable but almost essential. Without the standardization of such things as bolts, nuts, screws, and pipe threads and fittings, the manufacture and repair of equipment containing these articles would be complicated and expensive.

To a company in which *style* is an important factor, but which wishes also to obtain some of the advantages of standardization, a number of policies are available. It may limit the number of designs, but introduce a succession of them.

When a new pattern or model is developed, an older and slow-moving one is dropped from the line. The William L. Gilbert Clock Company, in following this policy, has limited its line to approximately seventy-five patterns, and its salesmen are prevented from taking orders for patterns for which the demand is small.

Again, where a company manufactures a line such as millinery, it is frequently possible to standardize the minor parts and linings rather than the design of the article itself. A third method is to single out a few items, or "leaders," that can be considered staple, and to make these to the exclusion of all other patterns. Moreover, the style element in a product may be confined to its color or finish. In such cases, the remainder of the product may be standardized; an example is sanitary ware, manufactured in color.

Problem of servicing items dropped. In certain industries, like those making machine tools, autos, and boilers, a problem which must be met is the continued servicing of models dropped from the line. This applies especially to assembled products, and to a lesser degree to certain type of textiles with which customers wish to match fabrics bought previously. A portion of the profits of some firms is secured from the sale of service parts.

Diversification. Diversification is the antithesis of simplification. Consequently, many of the reasons for pursuing a diversification policy result from the limitations of simplification. Manufacturers adopt the policy of diversification for the following reasons:

1. Nature of demand.
2. Stabilization of sales and production.
3. Greater profit stability.
4. Utilization of by-products.

Nature of demand. Change and diversity are the essence of fashion. A company engaged in a style industry cannot therefore fully avail itself of the advantages of simplification, because good styling gives such a company a competitive advantage. "Competitors find it simpler to give good quality and liberal value than to supply authentic styling. Whenever we advance our quality or reduce our prices, those moves are rather certain to be met promptly. But style has this competitive advantage for an alert manufacturer, that it changes continually and therefore if he keeps pace with it, he is likely to keep several steps ahead of most others." [3]

Custom production of a type not susceptible to simplification is frequently a profitable field of activity also. The manufacturer of custom-made clothing caters to a group that insists upon extreme individuality and is willing to pay for it.

Furthermore, certain products for which there are no satisfactory substitutes are absolutely required. It would be most economical for a pipe manufacturer to manufacture a pipe of one size only, like a two-inch one. However, it would be uneconomical for the consumer to use a two-inch pipe where a half-inch one will do the work. A company making wheels must be governed by the requirements of the vehicle manufacturer to whom these wheels are sold. A tire manufacturer must conform to the specifications of the automobile company. Such a policy requires cooperation between industries and frequently renders an individual plant powerless to act independently. Moreover, many customers prefer to do business with companies that can supply them with a "full line," thus placing at a disadvantage a company that offers a limited variety. This preference is encountered by manufacturing chemists, such as the Parke and Davis, and Merck companies.

Stabilization of sales and production. It seems paradoxical that industry should seek change to secure stability. The ideal condition for plant operation is one under which the demand for the product is constant throughout the year, yet few industries can attain such a condition because of seasonality of demand. Consequently, production may fluctuate in sym-

[3] A. S. Thayer, *Factory and Industrial Management*, November, 1932, page 425.

pathy. Product engineering can do much to "level" the production curve by designing products for the slack seasons. For instance, the Lycoming Motor Company took over the manufacture of the Spencer heater in order to utilize its foundry steadily. The American Ice Company, in addition to handling ice and coal, diversified by going into the laundry and dry-cleaning businesses, because 70 per cent of the ice business is done in the four months from June to September.

Excess capacity is the great creator of diversity. Once a plant cannot be kept busy, the hunt for volume begins. Almost immediately, executives seek new lines.

In addition, companies may feel that their unit selling expense can be reduced if their salesmen had a larger line to sell, and may add products for which their existing customers represent a potential market. However, products with which the company has neither production nor sales experience should be added only after the most careful investigation, and weighing all the dangers involved.

Greater profit stability. Diversification leads to greater stability of profits. If the demand for one line falls off radically, the remaining ones may carry the overhead. The company becomes less dependent therefore upon one class of customers. Diversification serves to protect a company against the long-run decline in the demand for a given line, and also against the ill effects of depression. In times of bad business, certain lines will continue to sell when the demand for others is stagnant. The beneficial effects of diversification are evident in the financial statements of such a company as DuPont. Its wide range of products, rayon, cellophane, nylon, powder, paint and varnish, and dyes, are sold to different groups of customers.

Utilization of by-products. The meat-packing industry is an example of diversification for the profitable utilization of by-products. Oil companies, although interested primarily in the marketing of gasoline and lubricating oil, make and sell cleaning fluids, liquid wax, floor wax, furniture polish, insect spray, and leather dressing.

Questions:

1. Why do you think the American Ice Company entered a radically different type of business? Suggest possibilities for supplementary lines.

2. Will simplification increase the size of sales orders?

3. Three textile companies making decorative fabrics and specialties which sell because of their individuality of design, their eye appeal, and their conformity to the style of the moment, find that the sales volume furnished by each 10 per cent of the number of patterns is as follows:

	Per Cent of Annual Sales		
	Company A	*Company B*	*Company C*
Lowest 10 per cent of patterns	.3	.4	.3
Second 10 per cent of patterns	1.1	.8	.8
Third 10 per cent of patterns	1.9	1.0	1.6
Fourth 10 per cent of patterns	2.6	1.5	2.5
Fifth 10 per cent of patterns	3.4	2.2	3.5
Sixth 10 per cent of patterns	4.4	3.6	4.8
Seventh 10 per cent of patterns	5.8	4.9	6.8
Eighth 10 per cent of patterns	8.5	7.7	10.7
Ninth 10 per cent of patterns	16.1	12.2	17.0
Tenth 10 per cent of patterns	55.9	65.7	52.0

(a) Do you believe that simplification of product is practicable in this case?

(b) How would you decide which patterns to drop?

4. When the Fayette R. Plumb Company reduced its lines of axes, hammers, and hatchets to some 600 items, what argument might its salesmen have employed to induce hardware jobbers not carrying these lines to handle Plumb tools?

5. A company making high pressure auxiliary power house equipment dropped its line of blow-off valves. Contrast its problem of servicing customers with that of a cereal manufacturer that dropped one of its breakfast foods.

6. Should a breakfast food manufacturer add a dog-food product?

7. Should a textile mill or cigar manufacturer attempt to market its "seconds"? If so, how?

CHAPTER 13

Quality Control

Nature of quality control. The control of quality is a twofold process: first, *producing* work of satisfactory quality; second, *inspecting* the product both when it is completed and while it is in process to detect work that is substandard. The first of these is a responsibility of the direct worker and of his line supervisors; the second is the task of those assigned to detect bad work. Inspection may be regarded as an integral part of managerial control. Once standards have been established, the management must inform itself as to departures from them if they are to be maintained by executive action. In the financial field, this leads to auditing; in manufacturing, it leads to the inspecting of incoming materials, work in process and the finished product, either before it is shipped or after it is in use by the customer. It is the judiciary of the production organization.

Quality standards and means of portraying them. The quality attributes desired by the customer and by the management must be expressed as definite standards if the quality of the product is to be assured. Since absolute uniformity is not attainable in practice, working standards must embody variations from the ideal. In deciding upon the liberality of these variations, the manufacturer balances their influence on the functioning of the product against their influence on production costs. It is important that quality standards be reasonable and attainable. Many an engineering department has unduly increased costs by requiring limits that are unnecessarily close. Moreover, quality standards should be so definite and specific that there can be no doubt in the mind of the worker as to what is required and what will and will not pass inspection.

The establishment of quality standards for a product should be the result of close cooperation among the sales, engineering, manufacturing, and inspection departments. The sales department interprets the needs and desires of the customer and brings a knowledge of competitors' goods to the organization; the engineering department knows the technical problems connected with the design of the product; the manufacturing department passes upon the manufacturing problems involved in the attainment of quality; and the inspection department advises upon both improvement of quality and reduction of inspection cost.

The desired size is a matter of dimension that can be expressed in writing and also in the form of gages. The permissible variations from the ideal size are expressed as tolerances, which may be defined as the error allowed in the size of a part. Dimensional tolerance is the distance between an upper and a lower limit. On blueprints it is customary to express these tolerances as the ideal or basic size ± the variation allowed. Thus the tolerance for a spindle for which the ideal diameter is 2.000 inches and the allowed variation on *both* sides .001 inch would be expressed as 2.000 inches ± .001 inch. This is called a bilateral tolerance; if allowed on one side only, it is called a unilateral tolerance and is expressed as 2.000 inches $\begin{matrix} + .001 \text{ inch} \\ - .000 \text{ inch} \end{matrix}$ or 2.000 inches $\begin{matrix} + .000 \text{ inch} \\ - .001 \text{ inch} \end{matrix}$.

When moving parts must fit together in an assembled machine, it is important to insure the proper space between them for oil and for freedom of movement. This desired clearance between mated parts is known as allowance. The tightest fit that will be satisfactory to the designer is the minimum allowance (.001 inch in the example below); the loosest fit is the maximum allowance (.003 inch). If the spindle with the unilateral tolerance were to be fitted into a gear with an inside diameter of 2.001 inches $\begin{matrix} + .001 \text{ inch} \\ - .000 \text{ inch} \end{matrix}$, the following combinations would be possible:

Gear:	2.001	2.001	2.002	2.002
Spindle:	2.000	1.999	2.000	1.999
Clearance:	.001	.002	.002	.003

Permissable variations are not confined, however, to dimensions; they apply as well to other quality attributes such as chemical composition, finish, color, taste, and smell. The percentage of sulphur allowed in steel will be controlled between certain limits, the finish of a steel part will be matched against certain samples, and color will be appraised by the intensity of lines on a spectroscope when the surface is illuminated by a constant amount of light.

In contrast, the quality specifications may concern performance. A metal product may be tested for physical characteristics, such as tensile strength, for compression, and for hardness as well as for chemical composition and such internal flaws as X-ray may reveal. Or the performance of a product may be tested by actual operation, as when a boiler is placed under pressure on the test floor, or an engine run on the block, or a finished automobile on the proving grounds.

Quality standards should be expressed in such a manner as to minimize the use of judgment in their enforcement. Attributes like size and composition can be set forth in written descriptions; dimensional tolerances can often be represented by gages. The color desired can be defined less precisely; in addition to the kind of color, its lightness or darkness, and its purity must be appraised. The required finish is also difficult to describe in specific terms, and management resorts to samples to indicate the distinctions between the finishes that are acceptable and unacceptable. For taste and smell, reliance must be placed on the highly developed senses of experts, such as tea tasters and tobacco buyers.

Gages. Of these tangible indicators of quality, gages are the most widely used and the most significant. The quality limits are built into limit gates; the lower limit is the "go" part and the upper limit is the "no go" part. If a part is kept within the limits, it will be suitable for assembly with other parts; if, however, it is not kept within them, the work of assembly will be wasted and the finished product will fail to perform satisfactorily. The closer the fit of parts the more serious is "growth" in size because of gradual wear of the tools used to machine them. Thus the closer the tolerances, the more frequently must the work of a machine be checked.

Gages, in addition to representing standards in specific form, also result in important economies. They permit inspection to be done by less expensive employees, and by mechanizing inspection they speed it up and enable inspection to keep pace with the mechanized mass production of parts and their conveyorized assembly. They permit the checking of parts with speed and precision. Where gages cannot be used, the checking of dimensions requires: first, the adjustment of the measuring device, such as a micrometer, to the part being measured; second, the reading of the measuring device; and third, the decision as to whether the size is acceptable. With gages, there is no need to determine the actual size of the part but merely if its size is within the limits. Consequently gages reduce the cost of inspection.

The gages in common use are of the fixed and indicating types. The first of these includes plug, ring, and snap gages. These are simple, reasonably rugged, and accurate. Plug gages are cylinders used for checking the inside diameters of holes; ring gages are for checking outside diameters of shafts, studs, arbors, and balls; snap gages also serve to check external diameters (see Figure 22).

Plug gages are sometimes built with one cylinder representing the lower limit ("go" gage), and a separate cylinder, the upper limit ("no go" gage). Or both the "go" and "no go" members may be on the same cylinder. If the "go" gage enters the hole being inspected, the hole is not too small; if the "no go" fails to enter, the hole is not too large. Such limit gages show the inspector whether the internal diameter being checked is within the limits.

With ring gages, the "go" and "no go" members cannot be combined in a single gage, and consequently separate rings are required to represent the upper and lower limits of an external diameter. These gages are most applicable to finished products, because a part being machined would have to be removed from the machine for the gage to be applied.

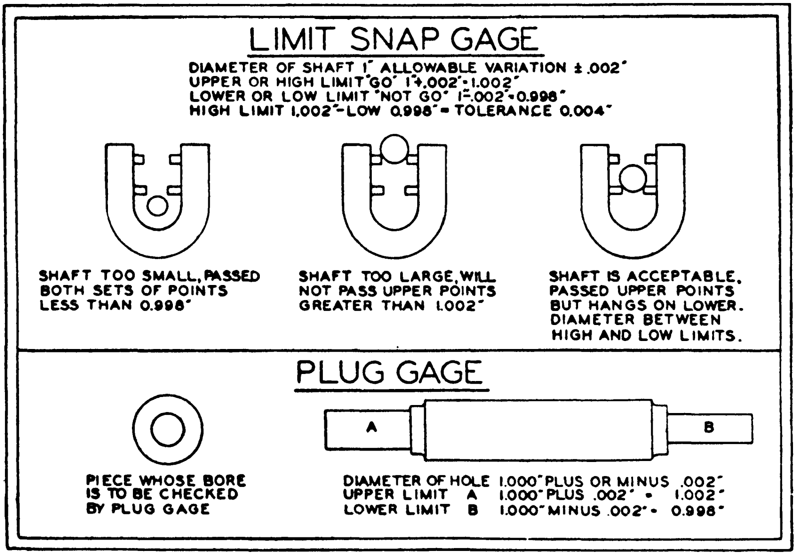

Figure 22.

Snap gages, both adjustable and non-adjustable, have the general shape of a caliper. They are applicable to volume work because they permit the fast, accurate, and easy inspection of parts that would otherwise have to be measured with time-consuming micrometers or vernier calipers.

Dial indicators (see Figure 23) serve to compare the dimensions of finished parts with the tolerance limits for which the indicator is set. The indicator magnifies the variation from the desired size and shows the results upon its scale. Two types are in use: the balanced scale indicator to show variations from a master setting; and dial micrometers that measure small dimensions by magnifying them before showing the results on the dial. An interesting variation of dial indicators are recording instruments, such as pyrometers, and other electrical control devices, such as thermostats.

Types of inspection. For simplicity, inspection methods may be divided into two broad categories: destructive, and non-destructive. The former includes tests of life, tensile strength, compression, and chemical compositions. All of these destroy the usefulness of the items subjected to test. Life tests simulate the conditions and strains of actual service to determine the resistance to them. Springs, shoes, fabrics, and electric switches are "worked to death" to determine their endurance. Parts are stretched or compressed to find out their tensile strength and their ability to withstand pressure.

Nondestructive inspection, by contrast, does the material, part, or product no injury. Used broadly, it encompasses not only the examination of internal structure by X-ray and magnaflux, but the measurement of dimensions and the visual examination of finish and other characteristics. Such visual inspection has to do with the surfaces of an object: it may be such a crude examination that it can be made with the naked eye or it may require the refinement of the microscope and of optical measuring devices.

Dimensional measurement may be as crude as the carpenter's rule or as precise as Johansson blocks with their accuracy of one two-millionth of an inch. Precision devices include the gages and dial indicators already discussed, micrometers, and vernier calipers. These last two devices have graduated scales and therefore have wide applicability to the measurement of length. They are used for checking small volume work that varies in size and shape. However, the fact that they require dimensions to be read from a calibrated scale causes their use

Figure 23. Sheffield Inspection Gage. Like a miniature traffic signal this electric gage flashes green, amber, and red lights to indicate to the operator whether the part checked is undersized, satisfactory, or oversized. It indicates with certainty any variation as much as one one-hundred thousandth part of an inch below the low limit or above the high limit of size specified on the production blueprint.

to be time-consuming and expensive. Consequently, on mass production operations where volume warrants the acquisition of gages, the latter are substituted because of the resultant inspection economies.

Maintenance of inspection instruments. As the result of use, limit gages and other inspection instruments wear out and become out of adjustment. Therefore, they should be checked periodically according to a definite schedule. For the purpose of inspecting gages, master and reference gages are employed, the master gage being used only for the purpose of checking the reference gages, and the reference gages in turn being used to check the shop gages. When no special shapes

CERTIFICATE OF INSPECTION

JOHANSSON GAGE BLOCKS.
C.E.JOHANSSON, INC., FORD MOTOR CO., DEARBORN MICH.

SPECIFIED SIZE	ACTUAL SIZE	VARIATION FROM SPECIFIED SIZE	RECOMMENDED REPLACEMENTS ACCURACY B	A	SPECIFIED SIZE	ACTUAL SIZE	VARIATION FROM SPECIFIED SIZE	RECOMMENDED REPLACEMENTS ACCURACY B	A
0.1001	.100085	.000015	X		0.133	O.K.			
0.1002	O.K.				0.134	O.K.			
0.1003	.100285	.000015	X		0.135	O.K.			
0.1004	O.K.				0.136	O.K.			
0.1005	O.K.				0.137	O.K.			
0.1006	O.K.				0.138	O.K.			
0.1007	O.K.				0.139	.138985	.000015	X	
0.1008	O.K.				0.140	.139988	.000012	X	
ETC.									

THE MEASUREMENTS ARE TAKEN IN THE CENTER OF THE MEASURING SURFACES.

GAGE BLOCKS MARKED O.K. ARE WITHIN ORIGINAL ACCURACY AT 68°F.

INSPECTED BY-ATLEE JANSSON

REMARKS- X=NEW BLOCKS

ACCURACY
(AT 68° FAHRENHEIT)
AA-.000002 INCH
A-.000004 INCH
B-.000010 INCH
PER BLOCK UP TO ONE INCH AND PER INCH OF LENGTH ON LONGER BLOCKS.
SET NO. 1-B
SERIAL NO. 739
DATE 10-16-1929

Figure 24.

are involved, Johansson Gage Blocks are frequently used. A set of 81 blocks will make more than 120,000 different-sized gages in steps of .0001 from a minimum size of .200 of an inch to more than 12 inches. Their extreme accuracy is recognized everywhere (see Figure 24). In addition, the photo-electric cell is an extremely accurate method of testing gages and other inspection appliances; in fact electronics inspection has come into its own not only for checking instruments but for process inspection.

Inspection problems. The questions to be settled are where and when to inspect, how much to inspect, and the choice of the most suitable methods. Inspection may take place either in a central "crib" or at the machines. Crib inspection means inspection is made in a room or cage separated from actual production. It does not imply the use of one room for all inspection done in the factory, or of even one room for a department, but rather the separation of inspection from actual production. On the other hand, the term "floor inspection" is used to designate the inspection of the work at the machine. In addition, "process inspection" may be a step in the sequence of operations, as in the conveyorized assembly of radios and automobiles.

Some of the advantages of crib inspection are that the inspection can be performed under ideal conditions with proper instruments, which results in greater accuracy and quantity; and that the inspector is not so likely to be influenced by workers. In addition, the use of less skilled inspectors is made possible because of better supervision in the crib. Crib inspection may be laboratory inspection, which is often employed in sugar refineries, and paper and steel mills. However, crib inspection is impractical if the size or weight of the product, or the nature of the process makes movement to a cage inadvisable. Its principal disadvantage lies in the cost of handling the material.

The principal advantages of floor inspection are that material-handling costs are lower, and that defects in production are likely to be discovered and remedied quickly.

The problem of when to inspect involves the number of the inspection points. These depend upon the importance of quality, and the economy to be brought about by discovering defects promptly so that additional operations may be avoided. In some cases inspection is confined to the finished product alone. In others an inspection is made after every operation or group of operations on each part and subassembly, as well as on the completed product. Because of the varied situations encountered, no general rule can be given to determine the number of inspection points. Each manager must work out his own solution. Briefly, however, his answer will be affected by the accuracy required, the skill of his labor, and the rapidity of changes in model or in quality. The most intensive inspection is therefore to be found where all of these factors are present simultaneously.

The number of pieces inspected at each point varies with the quality and the extent to which the work is done by hand. Some products require 100 per cent inspection, which means the checking of all pieces at each inspection point. Such inspection may be needed if the product requires a high degree of accuracy or if the operation affects following operations. On the other hand, if the product is machine-made, and if a high degree of accuracy is not important, the inspection of a smaller quantity may suffice. The opposite of 100 per cent inspection is therefore the "sampling" of a few units only. Sampling can best be applied to bulk materials like wheat, coal, oil, and steel, that may be assumed to be reasonably homogeneous, and to standard work of low unit-value that does not require a high degree of accuracy. Sampling, properly applied, is a means of reducing the amount and cost of inspection. Under this method several lots, selected at random from the batch, are considered representative of the quality of the whole. If the samples are satisfactory, the entire batch is passed without further inspection.

Methods of reducing inspection cost. The relation of the estimated cost of inspection in various industries is indicated by Table 3.

Among the measures that will aid in reducing inspection cost are the following:

1. A study of quality standards and product design to determine whether changes might save money.
2. An analysis of when, where, and how often the product

TABLE 3

INSPECTION COST BY INDUSTRIES

Industry	*Ratio of Inspectors to Workers* [1]
Ball Bearings	1 to 4 or 5
Small and Very Precise Interchangeable Parts	1 to 8 or 10
Automobiles, High-Grade Close Work	1 to 10 up to 1 to 20
Simpler Automobile Work	1 to 20 up to 1 to 40
Machine Tools	1 to 15 up to 1 to 40
Foundry and General Machine Shop	1 to 50

is being inspected, to determine points where inspection might be omitted.

3. When quality depends upon machine rather than manual operation, the inspection of the first part after the machine setup is changed.

4. An examination of the existing inspection instruments to determine whether more effective types might be used. There are a number of mechanical and electrical instruments that mechanize the inspection process, such as the automatic machine built by the A. O. Smith Corporation for the inspection of strip steel. This machine automatically sorts out pieces that are beyond the limits of length, width, or thickness.

5. The application of motion-study principles to the movements of the inspector. In one company where such a study was made, the time to inspect one hundred pieces was reduced from twenty to eight minutes.

6. The combination of inspection with other jobs. This, however, is not considered advisable except in special cases. For example, the counting of work and the making of minor repairs and adjustments can readily be combined with inspection. In general, inspection should never be combined with a job that is likely to divert the inspector from his principal function, the maintenance of quality.

7. The use of incentive payment for inspectors. Such incentives must be installed with great care to avoid the sacri-

[1] L. P. Alford, editor, *Management's Handbook*, page 738. New York: Ronald Press, 1924.

fice of thoroughness. They can be successful only if devised to encourage both speed and thoroughness, and if effective overinspection is provided. The term "overinspection" means the checking of the thoroughness of routine inspection. The idea of incentives for inspectors is not new; the method was used with success by Frederick W. Taylor in the inspection of bicycle ball bearings. Many executives think, however, that inspection work should be paid for on the basis of time rather than of production.

8. The use of statistical quality control and sampling.

Statistical quality control. Statistical quality control, based on the laws of probability, involves the designation of the practical limits beyond which variations should not go without correction. Such statistical control segregates the variations from random causes, which reflect pure chance or natural variability, from those variations that are unnatural and that call for remedial action. Normally only 46 measurements out of 1,000 will vary from the mean by more than twice the standard deviation, and 3 out of 1,000 by more than three times this amount.

Statistical quality control originated in the 1920's in the solution developed by Mr. Walter Shewhart of Bell Laboratories for problems that arose in the Western Electric Company. Later it was applied by the General Electric and Westinghouse companies, as well as Ordnance, Quartermaster, and other governmental agencies.

The accepted procedure for controlling quality statistically is typified by the method of the Westinghouse Electric and Manufacturing Company.[2]

In a manufacturing process, it is desirable to know, as soon as possible after production is started, what the quality of the product is likely to be. The "frequency distribution" is a simple way of obtaining this information. By measuring the quality characteristic in question on a number of pieces pro-

[2] This description has been condensed from *Statistical Tools for Controlling Quality* by Joseph Manuele, director of quality control, and Casper Goffman.

duced at the start of a run, a simple computation can be made to show the range within which measurements are most likely to fall for the subsequent production. Comparison of these limits with the tolerance limits shows whether the process should be allowed to continue or whether a change in the setup is required.

In a sample of 50 screw machine parts, whose length was required to be 4.450 ± .010, the actual measurements revealed that 16 were 4.450, 8 were 4.451, 7 were 4.452, 9 were 4.449, and 5 were 4.448. The remainder were within the range 4.454 to 4.447. The entire lot fell within the specification limits of 4.44 and 4.46.

It is evident, in this case, that the process is capable of producing good pieces and will continue to do so provided nothing happens to change the shape or location of the frequency distribution. A periodic check of five pieces per hour on this item suffices to show whether the frequency distribution remains unchanged. If the distribution does remain unchanged the entire production is considered to be within tolerance limits and final inspection may be dispensed with.

The centering and narrowing of the frequency distribution with respect to the specification limits guarantee that the product is of high quality. A frequency distribution has two characteristics that are of practical importance, the "central tendency" and the "amount of band spread" or degree of dispersion. Figure 25a is an example of a process for which the band spread, or the variation from part to part, is narrow enough to produce a good product if the machine were properly adjusted. However, the frequency distribution is not centralized with respect to tolerance limits. Figure 25b illustrates a frequency distribution that has a wider band spread than the tolerance range. Such situations may be traced to improper machine setups, worn bearings, unstable fixtures, and excessive variation in hardness of material.

After control of quality has been achieved by means of the frequency distribution and production is under way, it is necessary to maintain this control in order to avoid the production of defective parts. The control chart, derived from the frequency distribution is the tool used for maintaining this control. The mean, $\bar{X}$, and the standard deviation, σ, are calculated from the frequency distribution in order to

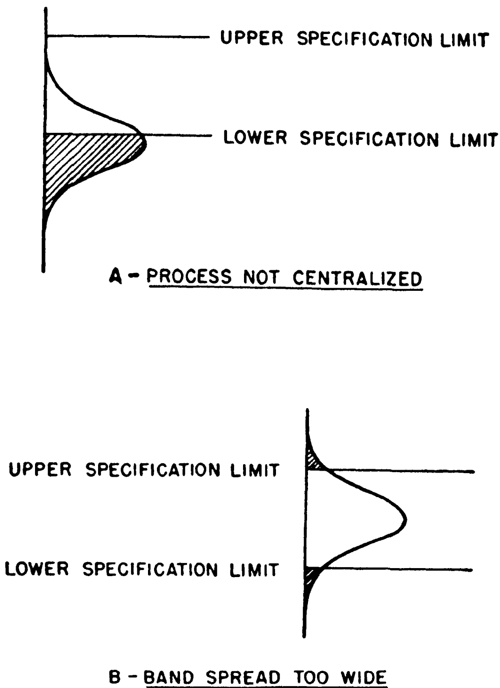

Figure 25 (a). Typical Frequency Curves Showing Assignable Causes.

establish limits for the chart. In many cases a rough approximation of these limits may be obtained from an inspection of the frequency distribution, but a common mathematical approach is to set the limits at three times the standard deviation.

As an illustration, consider the data of Figure 25b, which was obtained from a dimension on the breech block of an antiaircraft gun. The dimension is .6495″ ± .002″. As shown in the figure, a frequency distribution of 50 measurements was obtained and $\bar{X}$ and σ computed. The results of this computation are $\bar{X} = .6491''$ and $\sigma = .0007''$. Thus $\bar{X} - 3\sigma = .6470''$ and $\bar{X} + 3\sigma = .6512''$. Dotted lines are drawn at $\bar{X} - 3\sigma$ and $\bar{X} + 3\sigma$. These are called "control chart limits." In this example, 15 samples, each containing five measurements were then obtained—a sample a day for 15 consecutive days. As is apparent from the chart, all 75 measurements fall within the control chart limits. The process is accordingly considered to be "in control."

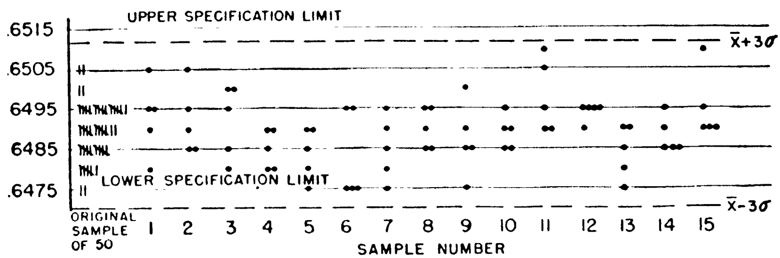

Figure 25 (b). Typical Control Chart for Sample of Five Pieces, Showing Individual Observations.

After it has been established that the mean and the standard deviation are satisfactory for the process and a control chart has been constructed, a periodic check, of say five pieces, is sufficient to detect tendencies toward loss of control. Sampling is governed by such factors as tool wear, skill of operator, closeness of specification limits, and rate of production. If any measurements fall outside of these limits, this is a strong indication that a change has occurred in the process at those points that has changed the frequency distribution.

The control chart frequently shows the source as well as the existence of trouble. Most machine shop operations are essentially simple, and the likely causes of lack of control are few in number. Therefore it is easy to discern the causes of ranges out of control and of averages out of control.

Mr. O. H. Somers, formerly quality control engineer, Standard Gage Company, Inc., reports an example of the saving from applying such control to a centerless grinder for parts having a tolerance of .0003 inches. Without control, 11 per cent of the parts were outside of the tolerance; with it, all the parts were within the limits. Before control the cost per 100 acceptable pieces was $4.15; after control, it was $0.74 including an allowance of $0.25 for keeping the chart. The saving resulted from the elimination of the defects and a reduction in the time lost making machine adjustments.

Statistical sampling. An alternative to 100 per cent inspection is acceptance testing that, like statistical quality control, is based on probability theory. The risk of accepting a substandard lot or of rejecting an acceptable lot can be reduced, theoretically, to a certainty that approximates the thoroughness actually obtainable with 100 per cent inspection. In fact, Mr. Somers illustrates how monotony, ineptitude, carelessness, and lack of attention by the inspectors makes 100 per cent inspection unreliable. A recheck of material accepted after 100 per cent manual inspection revealed 22 per cent to be defective, and a recheck of six lots of finished stock, selected at random, disclosed defects averaging 17 per cent.

Before statistical sampling can be used, the management must define what constitutes an acceptable lot and provide instruments of sufficient precision to discriminate among small variations. Management's decision as to the acceptable quality level should reflect the accuracy with which an operation can be performed economically. Mr. C. W. Kennedy, quality control engineer, Federal Products Corporation, suggests that it is uneconomical to attempt to force a screw machine department to attain a quality level of better than one or two per cent defects.[3] Once the acceptable quality level has been decided, a sampling table may be developed from mathematical formulae to indicate the size of sample for a certain quantity of material or pieces. From the number of

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[3] American Management Association, "Practical Applications of Quality Control." *Production Series Number 173,* 1947, page 27.

1 No. of Units Inspected	2 Acceptance Number	3 No. of Defects Observed	4 Rejection Number
1	—	0	—
2	—	0	—
3	—	0	—
4	—	1	4
5	—	1	4
6	—	2	4
7	—	3	5
8	—	3	5
9	—	3	5
10	—	3	5
11	—	3	5
12	—	4	6
13	—	4	6
14	0	5	6
15	0	5	6
16	0	5	6
17	0	6	7
18	0	6	7
19	0	6	7
20	1	7	7
21	1		7
22	1		7
23	1		8
24	1		8
25	2		8
26	2		8
27	2		8
28	2		9
29	2		9
30	3		9

The sequential method of acceptance sampling is illustrated above. The form containing columns 1, 2, and 4 is prepared by the statistician, who considers such items as the risk of accepting a bad lot. The inspector keeps a cumulative total in column 3 of the number of defective pieces. As soon as this total matches either the acceptance or rejection number, testing stops and the appropriate action is taken. In the case shown, 7 defective pieces were found among the first 20 examined. Hence the lot was rejected.

Figure 26.

defects in the sample, their probable number in the entire batch can be calculated.

A refined form of acceptance sampling is sequential analysis. Under this method the size of sample is indeterminate, but it is about 50 per cent smaller than with fixed sampling methods. Hence it is especially useful for tests that are destructive. For each size of sample, the sampling table (see Figure 26) indicates an acceptance number and a rejection number. The number of observed defects and the total number of units tested are both tabulated. When the number of defective units reaches either the acceptance or rejection limit, testing is discontinued, and the batch is either accepted or rejected.

Questions:

1. Discuss the pros and cons of applying incentive payment to inspectors.

2. How might changes in design affect the cost of inspection?

3. Should a manufacturer raise or lower his quality standards in periods of business depression?

4. Assume that the line executives connected with manufacturing are the general manager, works manager, superintendent, assistant superintendent, and foreman. To which of these would you have the inspector report in the following industries?

(a) Broom manufacture.
(b) Soup canning.
(c) Paper-towel making.
(d) Automobile manufacturing.
(e) Manufacture of electrical equipment.

5. On what basis could operators be rated in accordance with the quality of their workmanship? Is a record of the percentage of defective products sufficient?

6. Would you employ centralized or floor inspection in each of the following industries?

(a) Manufacture of radios.
(b) Manufacture of locomotives.
(c) Manufacture of ball bearings.
(d) Shipbuilding.

7. On the basis of the following information, would you place an inspector at $60 a week after each operation? The data concerning throw-outs (rejections) were collected by inspectors during a test period of a week, and the cost information was supplied by the accounting department. Assume that the product must be given a final inspection after operation #6.

Operation	*#1*	*#2*	*#3*	*#4*	*#5*	*#6*
Throwouts per week	400	300	90	150	60	10
Cumulative cost of part after each operation	$2.00	$2.20	$2.40	$3.00	$3.40	$5.00

8. What steps may be taken to indoctrinate the work force with the importance of quality?

Section V

MATERIAL CONTROL AND PROCUREMENT

CHAPTER 14

Purchasing

PURCHASING is in juxtaposition to selling, and the purchasing department is the "receiving line" of the business.[1] Consequently, it must be staffed by employees who are qualified to meet salesmen. If a purchasing agent is poorly informed or disagreeable, his company will lose many a useful tip. He will fail to attain those results which a company has the right to expect from its purchasing department. The objectives of purchasing are contained in the statement "to secure the right material, in the right amount, at the right time, and at the right price."

In this discussion, the function of purchasing is considered as an activity common to every business, an activity that is sometimes insignificant and sometimes of outstanding importance. Many of its problems are encountered in similar form by manufacturing plants, financial institutions, and mercantile houses. Still others are peculiar to the industry and kind of business. In the food industries, such as sugar refining, meat packing, and flour milling, in which over 70 per cent of sales income is paid out for raw material, purchasing is especially vital. Its importance is also enhanced whenever the raw material prices tend to fluctuate widely. When these two tendencies are both present, purchasing mistakes result in tremendous losses, and shrewd buying means large gains.

[1] Specifically, the purchasing function has to do with the procurement of materials, semifinished parts, supplies, machines, and equipment. In its broadest meaning, it includes all of the activities related to procurement, such as the control of inventories and so forth. In this treatment, however, the term is used in its narrower sense.

The opposite situation is found in those industries whose raw material costs absorb only a small portion of their sales income. In the manufacture of office machines, sewing machines, cement, and copper smelting, the cost of the raw material runs from 10 per cent to 20 per cent of the sales dollar.[2] Of course, the importance of the purchasing function tends to diminish in companies that are vertically integrated. If one department of a plant passes its products along to the others, the relative amounts paid to outside suppliers are reduced.

The most important directions in which purchasing, properly accomplished, tends to reduce costs are outlined below. The last three of them apply equally to the control of inventories.

> Reduction in the first cost of material.
>
> Economies that result from buying materials or supplies most suitable for the purpose.
>
> Prevention of delays by having on hand the material or supplies when needed. Underbuying may endanger sales by delaying deliveries or preventing the acceptance of orders. Moreover, plants designed to run on a continuous process basis usually have such a large investment in machine equipment that overhead rates per hour are high and in consequence delays are all the more costly.
>
> Avoidance of obsolescence and losses resulting from price decline. It is important to keep the capital investment in inventory as low as is consistent with the manufacturing program.
>
> Overbuying creates the risk of loss from deterioration or decline in value.

It is, of course, important to buy material at the lowest first cost obtainable, but it is just as important—if not more so—to consider the effect of the material on the total manufacturing cost. For example, steel castings that were entirely satisfactory were being purchased by a machine shop from a certain foundry when another offered its castings at a lower price.

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[2] National Industrial Conference Board, "Rebuilding Industry's Sales Organization." *Studies in Business Policy,* No. 3.

The buyer "switched" to the second foundry, but the castings furnished by it were annealed improperly, with the result that tool breakage and machining time increased.

Who should do the buying? In general, buying is done by a purchasing department. The person in charge, known as the purchasing agent, usually reports to the executive responsible for production. However, in companies where inventory losses through price declines overshadow any likely losses in the plant, the purchasing agent frequently reports to the treasurer.

Although the practice is not common, certain types of manufacturing establishments coordinate their purchasing with sales, as in the ordinary retail business. The packing industry is a good example. In the large packing plants, the control of buying and selling is centered in the product department as distinguished from the manufacturing departments. The finished products are determined to a considerable extent by the grade of raw material available. Prime beef cannot be obtained from "canners," nor would grade *A* steers be used for corned beef. For bacon, one type of hog is preferable, and for ham, another.

The question of who is to do the buying leads us at once to one of the most difficult aspects of management, namely, organization. In the case of the purchasing activity, the assignment of responsibility to given individuals or departments involves decisions on two matters:

1. To what extent should purchasing be functionalized—that is, taken away from foremen and department heads?
2. To what extent should its control be centralized—that is, controlled by a single department?

It is now almost universal for the general control over purchasing to be functionalized. Of course, long after a functional department has been created, certain influential officers may wish to do some buying personally, or to specify the sources from which goods are to be secured. Those departments that are centralized are usually functionalized also, because functionalization assigns to specialists the responsibility for procurement. The converse is not necessarily true, except in small companies. Large corporations ordinarily place the activity under functional control, but have part of it done centrally and part locally.

As to the extent to which functionalization has been carried by manufacturing plants, one must differentiate between three kinds of decisions:

1. The writing of the specifications (which, in effect, determines what is to be bought).
2. The computation as to how much should be purchased.
3. The decision concerning the price to be paid.

Although there is a tendency in the larger companies for the specifications to be written jointly by a number of departments, it is an almost universal practice to hold the engineering department responsible if the product involves great precision. Although the purchasing agent may ask questions and make suggestions concerning specifications, it would ordinarily be unwise to leave the decision as to what should be bought entirely to him. He is scarcely in a position to decide that the company should buy oil instead of coal, or rubber belting in place of leather, or rayon in lieu of silk. Among large companies there is a growing tendency for the quantity ordered to be decided by a materials control department.

The decisions concerning the price at which an order will be placed and the actual issuance of purchase orders are universally controlled by the purchasing department in the case of supplies and unimportant items. With respect to raw materials, however, an authorization by a top executive is often required.

In an automobile company, the vice-president of manufacturing controls the purchasing of raw materials, as well as production planning and other activities. However, the quantity to be ordered is based on the master schedule furnished by the sales department, and the quality standards are determined by the engineering department. In an elevator manufacturing company, the purchasing agent likewise reports to the works manager, but materials bought in bulk and on long-term contracts are supervised by the president. The quantity is determined by the stock department, a subdivision of purchasing, and the quality desired is set by the engineering staff. In the Bayuk Cigar Company, a vice-president buys all of the tobacco, except the Sumatras, which are bought by the chairman of the board. All other materials and supplies are bought by a purchasing department, which acts on requisitions from the department heads. The latter determine the quality and quantity desired.

The second organization policy to which we have referred concerns the degree of centralization. In general, the more uniform the product and the operations of the several plants of a company, the more the control of purchasing can be advantageously centralized in one spot. This is true, for example, of the railroads and the utilities. In favor of decentralization, one often hears the argument that no one person can be sufficiently familiar with all the items he is called upon to purchase. The argument, in other words, is that only the user of an article can properly buy that article. The appropriate answer to this argument has already been intimated, as the decision regarding what is to be bought should be determined primarily by engineering design, or by the head of an operating department, with the purchasing department merely advising.

On the other hand, centralized buying attaches the responsibility for attaining the desired objectives upon one or more individuals with specialized training. It also enables a management to follow consistent policies in dealing with its vendors and to use a uniform purchasing procedure throughout the company. Furthermore, by combining the requirements from all parts of the enterprise, it enables the company to take advantage of quantity discounts.

Corporations whose plants are geographically separated have found that the distance between them creates problems in meeting emergencies and in filling their needs for special articles. In such cases the above arguments for centralization are sometimes outweighed by the chance of delay and misunderstanding. The answer is to locate at each plant a local purchasing agent, who follows the policies of the central purchasing department and, for standard materials, merely places orders against contracts that have been made by the home office. But in case of emergencies and special items, these local agents hunt for sources near at hand. In a paint plant the local supplies are bought by the purchasing department, which reports to the manager of each plant, but bulk items are bought on contract by the centralized purchasing department. Or, the general purchasing department is in the headquarters office, with local buying in charge of the material supervisor, who reports to the works manager.

If a company desires to change from a decentralized form of organization to a centralized one, it is likely to find that a frontal attack on the problem of transition results in the opposition of plant executives and in dissension among the purchasing personnel brought together from the several branches into one large department. Some corporations have therefore adopted the expedient of establishing a central purchasing committee whose chairman is vested with the power to establish purchasing policies for the whole enterprise. This plan has the advantage of insuring flexibility, and at the same time profiting from large-scale buying on uniform specifications.

Selection of what to buy. As already indicated, the decision as to the exact nature of the items to be bought is expressed in well-run companies by written specifications. It has also been indicated that in the preparation of these specifications the chief responsibility should rest either upon technical specialists, such as those engaged in designing, or upon the heads of the departments in which the articles are used. The purchasing department, however, may assist in their preparation by pointing out how advantage may be taken of commercial usage to effect economies, and by apprising other executives of new substitutes and sources. The cost department is also in a position to render worthwhile help by making a complete analysis of the comparative costs of fabrication of competing materials or parts. If the cost of fabrication is found to be lower, it may prove advisable to substitute material that is more expensive than the one now used. For this reason managers sometimes replace steel with brass, and castings with drop forgings, pressed steel, or stampings. Such a change in materials may completely eliminate some of the manufacturing steps.

The items purchased by companies may ordinarily be classified in either of two ways: according to the degree of standardization, and according to the type of commodity they represent. To illustrate differences in standardization, we find at one extreme branded articles (for example, Le Page's glue) and highly standard materials (for example, cement), and at the other, unstandardized articles (as a house) for which the specifications must be detailed. Classified as to type of commodity, the items ordinarily bought include raw materials that will be consumed or changed in form during manufacture; manufactured goods purchased from others for assemblage with other parts prior to resale; and machines, equipment, and supplies. Typical of manufactured parts are such things as bolts, rivets, buttons, castings, and electric motors; and of equipment and supplies, coal, lubricating oil, drills, and wheelbarrows. Naturally, industrial equipment far outranks supplies in importance, because the former, representing items such as trucks, machine tools, boilers, and conveyors, involves large capital expenditures. Consequently they must be selected with extreme care to avoid tying up money in equipment that does not fit the need.

If the goods are of standard quality and form, and if the reputation of the vendor, or brand, can be relied upon, *mere description* is often sufficient. This method would ordinarily be used in the purchase of automobiles, watches, cement, brick, and bread.

There are other items which cannot be easily described and for which detailed specifications cannot be prepared. In style goods, such as millinery and ladies' ready-to-wear clothing, the unstandardized nature of the article and the intangible element of style may necessitate *personal selection* based on an examination of the actual merchandise.

For many of the materials, semifinished products, and supplies purchased by factories and large financial and commercial houses, *detailed written specifications* are both possible and desirable. Provided they meet commercial usage, they broaden the competition for the business to be placed, and thereby tend to secure more advantageous prices. Perhaps the outstanding examples of the use of these specifications are found in the construction of houses and office buildings and in the steel fabricating industry, since each job is highly specialized.

Sometimes a particular quality of material best serves the given requirements. If materials are purchased which are far better than necessary, needless expense is incurred. On the other hand, a loss may be sustained if materials of too low a quality are used. Thus specifications are of great importance to the purchasing department in order to make clear to the vendor what he is to furnish and in order to eliminate misunderstandings and disputes.

Considered broadly, every request for goods to be purchased is a rough specification. The problem of drawing up specifications, therefore, is to make certain that they are definite and meet commercial practice. A good purchase specification should describe accurately and specifically the properties of the article desired and the methods of inspection and testing. It should be worded as simply as is consistent with clarity, and adhere as closely as possible to recognized practice. The use of specifications makes it possible to inspect the quality of material furnished, and helps to secure materials good enough, but not too good, for the buyer's purpose. They permit more vendors to bid on an equal basis, and therefore enlarge the sources of supply.

One of the most interesting questions of policy connected with the nature of the articles bought is whether a manufacturer should purchase semifinished parts from outside, or should make these items in his own plant. Naturally, if the quantity is small, he will tend to buy them outside, and in so doing, he will not only retain the privilege of shifting to new suppliers if they offer him improved articles, but he will lessen the risk attendant upon "freezing" his own capital in specialized machinery. He will also tend to buy outside if his working capital is limited. It would be difficult, for example, for a company trying to break into the automobile business and having a restricted amount of credit to make all the parts going into the finished car. For one or more of these reasons, a large percentage of motor parts are made in quantity lots in specially equipped plants, and bought from them by the car manufacturers. It is quite common for the car manufacturers to purchase carburetors, radiators, electric generators, and starting motors.

Where should purchases be made? It is often said that the choice of suppliers represents the most important duty of the purchasing agent. In developing and maintaining adequate sources of supply, it is usually important to secure the benefit of competition, and if the volume warrants, to establish relations directly with producers instead of with middlemen. Moreover, it is not considered good buying policy to consider sources that have rendered unsatisfactory service in the past, or that cannot offer advantageous freight rates. Knowledge concerning sources of supply is thus essential if a plant is to secure consistent quality and satisfactory service. It is quite evident, therefore, that knowledge of available sources is a primary qualification for purchasing. Large plants use catalogue files, trade directories and journals, and records of vendors; in addition, they take advantage of information gleaned from interviews with salesmen.

If the purchasing officer is friendly with his suppliers, they will be inclined to give him advance information on price increases. Moreover, the closer his relationship with them and the more intimate his knowledge of their problems, the more easily he can meet an emergency, such as the securing of supplies in case of an unexpected shortage, or adjustments in case of a sudden decrease in demand.

The two most interesting questions of policy concerning buying sources are whether or not a corporation should split its orders, and whether or not it should engage in reciprocity arrangements.

The basic reason for splitting orders is, of course, to have an assured supply. Often the sources of raw material supply are highly localized, and their control is in relatively few hands. This condition is true for certain kinds of coal, limestone, and timber; whereas the opposite is true for building brick. If the source of supply is limited, the danger of its loss is so serious that a manufacturer will seek either to acquire the source or to make a long-term contract with the supplier. In deciding the proper answer to the question whether to cultivate one source or several, it is advisable to maintain a balance between keeping several sources of supply open, and making purchase orders sufficiently large to command low prices. The latter are affected, of course, by the ability of the supplier to effect economies in his own plant.

Undoubtedly the most serious organization difficulties faced by a purchasing officer are created by pressure from the sales department to practice reciprocity, that is, to favor with purchase orders those firms that, in turn, buy the company's products. It is a scheme of mutual backscratching on the part of two enterprises. Although such a practice tends to make for less effective purchasing, it is nevertheless employed extensively. In fact it is unusual to find a large corporation that does not use the weight of its purchasing power to push its sales by reciprocal arrangements. A distinction should be made, however, between defensible reciprocity and indefensible reciprocity.

Reciprocity is practiced in two different ways:

1. The favoring of suppliers whose price and quality of product are on a par with those of others.

2. The favoring of suppliers having higher prices and/or inferior products.

The latter is whole-heartedly condemned by purchasing agents, but not at all by many sales executives. Whether or not the purchasing department is forced to accede depends upon the policy of the top management, and the purchasing agent will often find that the matter is beyond his control. If this type is practiced, the top executives might well insist, in order to secure a clear view of the situation, that the additional cost of the goods thus purchased be charged to the sales department. The latter can then decide whether or not reciprocity with a given customer is worth while or too costly.

Reciprocity of the other type (that is, when price, quality, and service are on a parity) is easily defended as a builder of good will, provided the arrangement is felt to be of mutual advantage. But in practice, the application of the policy strikes a snag in determining equivalent quality and service. Moreover the supplier is very likely to resent the idea of becoming a customer by force.

The method by which a large corporation makes use of the reciprocity principle is to advise its salesmen as to the items it buys and where, and to coordinate the awarding of purchase orders with the objectives of the salesmen. Professor H. T. Lewis remarks that some companies have set up separate departments to bring reciprocity arrangements under centralized control.[3]

How much, when, and at what price to buy. The technique for deciding how much is required of a given item is treated

[3] H. T. Lewis, *Procurement*, page 417. Chicago: Richard D. Irwin, Inc., 1948.

later under Inventory Control; the present discussion is confined to the more general questions of policy. The decision concerning the proper quantity to purchase is inseparably linked with questions of time and price. At the time prices appear to be very low, a company will be tempted to "stock up"; when prices seem high, a cautious management will buy only "from hand to mouth." Obviously there is no foolproof method of arriving at the best decision at a given time. The judgment of the top executives can be supplemented on the one hand by statistical information as to the probable trend of prices, and on the other by the company's estimated requirements. Though small firms cannot afford to keep a separate statistical department, they can secure statistical data from many outside sources.

The principal policies followed with respect to quantity, time, and price are known as *hand-to-mouth buying; forward buying;* a variation of the latter, sometimes called *averaging down; speculation;* and *hedging.*

Hand-to-mouth buying should be used when prices are uncertain or are falling very rapidly. It also fits the situation when the company's needs are uncertain. Such a policy quite obviously limits losses from price declines, but if pursued at the beginning of a rising market, it leaves a company in the same position as that of a well-known rubber manufacturer who had low stocks of crude rubber at the time the Stevenson Act raised the price of the product.

Forward buying is purchasing for future needs. If the contract calls for a given quantity of an article for delivery at a future time, the price may or may not be specified. The policy of forward buying is followed when prices seem likely to rise and the probable consumption warrants purchases in large quantities. The wisdom of this plan, as affected by price trends, can be partially checked by data as to stocks on hand (as in raw silk and cotton), and by comparisons of price with available data on production costs, obtained from all sources. The future consumption depends on the sales volume of the company in question. Such buying is often accomplished by means of long-term contracts on the theory that the combination of volume and continuity permits the supplier to secure economies in selling, in production, and in the buying of his raw materials. In making long-term contracts, the orders given to each firm should be large enough to permit quantity production. In addition, small orders should be placed in the open market, to keep in touch with new developments and with price changes. The use of long-term contracts is in contrast to that of vertical integration, but it permits economies of a similar nature, that is, reduction in the expenses of selling, buying, inspecting, and handling of orders. Because of the length of the period covered, the price is customarily made subject to adjustment on some basis agreed upon.

Averaging down on the market means the purchasing of a portion of the company's needs when the market dips sharply in the course of a gradual price change. Such a policy is advisable only when the consumption needs are definite, and can be used to accumulate a stock by taking advantage of fluctuations in price, or to fill requirements during a period of falling prices. Prices rarely rise or decline evenly, but follow a saw-tooth pattern. Consequently this policy, if followed successfully, results in prices lower than the average for the period. The effect is shown by Figure 27.

The problem of when and how much to buy cannot be dismissed without facing the difficult question of speculative purchasing. The purchase of almost anything, even a government bond, involves some risk. To an unusual extent this problem is a relative one, and the distinction between "forward buying," speculating, and gambling is a question of judgment that can be settled only in the light of given circumstances.

Speculation represents any change in normal buying habits for the purpose of taking advantage of an expected price change, either upward or downward. It is usually thought of in connection with the purchase of quantities larger than those needed. The term might be applied equally well to the refraining from normal buying (that is, reducing the stock on hand to a point dangerously low) in order to take advantage of an anticipated price decline. One of the advantages of speculative buying is that, if done shrewdly and cautiously, it adds to profits. A manufacturer of worsted yarn has remarked that over several decades his spinning alone would have yielded him little profit and that any appreciable profit

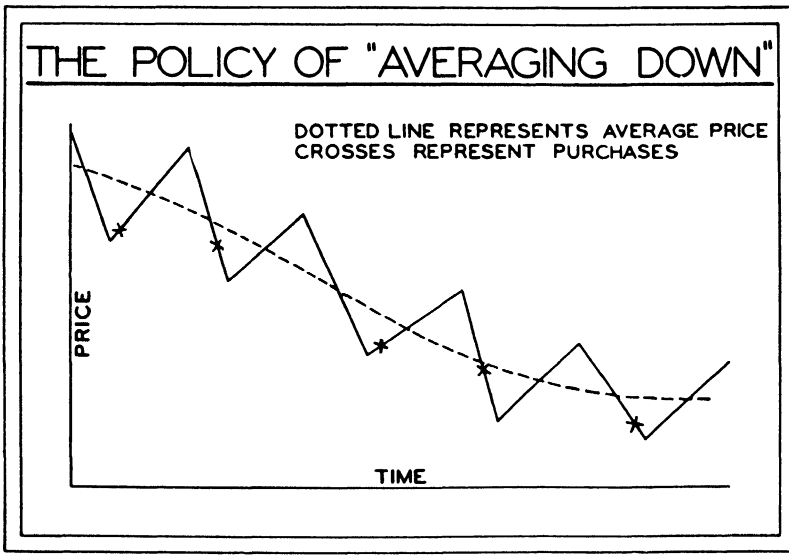


Figure 27.

he has made is traceable to advantageous buying. On the other hand it is far safer for a company to confine its activities to its regular manufacturing operations. Consequently many firms abjure speculation entirely by hedging. The majority of companies, however, follow a middle course between these two extremes, one that takes advantage of their knowledge of raw materials but limits the possible losses to what the company can stand.

The problem, in essence, is therefore one of comparative gains and losses. A management that buys in expectation of a price rise not only runs the risk of faulty judgment, but also incurs extra costs for insurance, storage, and so forth. A management refraining from speculative purchasing foregoes any profit that might result. Yet the problem affects a company so vitally that it can be said with complete assurance that no speculation should be carried on without receiving the authorization and the best advice of the top management. The matter should not be left to the discretion of the purchasing department. Moreover, if speculation is carried on, the management should frankly recognize the nature of its decision and proceed only with its eyes fully open to the possible eventualities. It is sound financial policy to set aside speculative winnings as a reserve against losses from transactions in which the management's judgment proves bad.

Gambling, as distinguished from speculating, is encountered in business when executives buy materials with which they are unfamiliar, or buy quantities far in excess of normal needs on the chance that prices of similar articles will rise. In buying, gambling is speculation run wild.

Hedging, on the other hand, eliminates speculation. Gains or losses on materials that are on hand or are required for sales orders, can be offset by dealing in "futures." In practice, this method can be used only when there is an organized market for the material.

Problems of competitive bidding. The analysis, even if it has to be approximate, of the costs of manufacturing the articles to be purchased is an important aid in negotiating more advantageous prices. Akin to analysis of production costs is the analysis of bids submitted with a view to their revision. In theory, a policy of firm bidding is sound and should be departed from only when there seems to be collusion among the bidders, or when the specifications seem to have been misinterpreted. The advantages of firm bidding are that it treats all suppliers alike, and lessens the temptation on the part of suppliers to use inferior materials for those specified. In addition, it avoids the necessity of constant bargaining after the bids are submitted.

Actually, however, revisions are very common. Especially in times of falling prices, the purchasing agent is under pressure from vendors for permission to revise their quotations. Or he may desire revisions, for example, if he suspects collusion, and can adopt one of three courses: he can accept the situation meekly; he can seek new sources of supply; or he can reject all the bids and attempt to bargain with one or more of the suppliers to get the price reduced. The feeling usually prevails that it is just as ethical for purchasing agents to try to force down prices as it is for suppliers to try to keep them up. It is ordinarily considered good practice to accept the lowest bid, provided it has been submitted by a reliable firm. Moreover it seems only fair to restrict the bidding to those firms considered sufficiently reliable to be awarded the contract.

Purchasing routine. The purchasing procedure should be simple yet adequate. It must be definite and sufficiently flexible to be expanded or contracted with the volume of purchases.

The routine for a purchase transaction usually begins with the transmittal of the requisition to the purchasing department by someone with the necessary authority. No requisitions from other sources should be accepted. Before negotiation for the goods can be undertaken, the purchasing department must choose the vendors with whom it will deal, and send an inquiry to each of them. These vendors send back proposals from which one is selected; and the purchase order issued. The terms of the purchase order govern the transaction unless it is mutually agreed to substitute other conditions. Purchase order forms in use vary tremendously. So far, attempts to make them uniform have not achieved much success. The number of copies ordinarily varies from two to eleven. The original is sent to the supplier; one, to the department using the material; another, to the receiving department for filing under the vendor's name until the goods arrive;

and one is kept in the purchasing department. In the ultimate disposal of purchase forms, it is almost universal practice to keep a file of approved invoices and of purchase orders. It is convenient to have purchasing department information filed in at least three ways: by vendor; by item; and by purchasing order serial number.

The important work of following up orders to insure delivery as promised requires a tickler file of orders outstanding. In small companies, the actual follow-up is done by the telephone girl between calls.

When the invoice arrives, it should be checked against the purchase order and the actual merchandise. Inspection as to quantity and quality is done by either the receiving or the inspection department. The checking of prices, terms, and extensions may be done in the accounting or purchasing department. If such checking is done in the former, accounting work is kept in a single office, and checks and balances are provided to prevent dishonesty. Yet, it is simpler to do the checking in the purchasing department, for those who have filled out the purchase order are in a position to check it more intelligently.

Questions:

1. Does the buy-at-home principle differ from reciprocity in its effect on the purchasing agent?

2. Do you consider it good policy to let salesmen enter the plant to interview the superintendent and the foremen?

3. Would you favor the adoption of a rule limiting the interviews with salesmen to certain mornings of the week, or to a few hours on specified days of the week? If not, how would you meet the problem, encountered in recent years, of an increase in both the number and the length of calls?

4. To obtain a competitive price is it necessary to split orders?

5. How is buying on specification related to the volume of goods bought?

6. Argue the propriety of the receipt by a purchasing agent of Christmas gifts and of entertainment.

CHAPTER 15

Inventory Control

THE factors of stability of manufacturing and prompt delivery to the customer require that "pools" of parts and materials be maintained at various points in the production process. These "reservoirs" are technically known as inventories. If they are held at the beginning of the manufacturing process and consist of goods consumed or transformed en route, they are called *raw materials and supplies;* if they are kept as component parts for assembly, they are known as *finished-parts stores;* if they are maintained as completed products ready for shipment, they are called *finished stock.* Moreover, even though the volume of business is small and the production cycle short, a certain flow of material is always being worked upon. This material consists of the partially manufactured "product," called *work in process.*

Not every manufacturing concern, of course, will have all of the above classes of items, nor will each class represent the same proportion of the total inventory.[1] For instance, the amount of raw materials carried will depend upon the purchasing policy of the company, the degree of correlation between purchasing and production, and the nature of the business. Forward and speculative buying tends to increase the size of raw material inventories, whereas hand-to-mouth buying keeps them at a minimum. If deliveries of raw material are synchronized with production requirements, stocks of

[1] *Finished-parts stores* are found in plants producing assembled articles, such as electric motors and oil circuit breakers; but in such businesses as cigar manufacture, sugar refining, and yarn dyeing, they are non-existent.

raw materials on hand may be minimized. Bayuk Cigars, Inc., "cure" their cigar tobaccos for three years prior to processing it. This method obviously implies large supplies of raw materials. Oil-refining companies buy crude stocks as they come on the market, and carry them in storage areas.

Businesses requiring tremendous inventories of raw and worked materials are those producing tobacco products, textiles, oil, meat, sugar, tires, apparel, fertilizers, and agricultural implements. In contrast, shipbuilding, food-products, and electrical-equipment enterprises illustrate types of businesses in which relatively small inventories are necessary.

The size of work-in-process inventories is influenced by the effectiveness of production control, the use of conveyors, and the methods of manufacture. A lackadaisical control of production may result in excess materials around the shop, and in shop delays and congestion. In a tool-manufacturing establishment, the use of a process conveyor in the finishing department reduced the average daily inventory from about 15,000 to some 300 tools, and in an automobile plant the introduction of group incentive reduced work in process by 50 per cent. Where a long, slow process is involved, as in the bark tanning of leather, work-in-process inventories will be high.

The amount of finished-parts stores and of finished stock is directly related to purchasing, selling, and financial policies, and is influenced by the extent to which sales and production are correlated. Where parts are purchased, their delivery to the plant may be synchronized with production requirements, and finished-parts inventories can be kept at an absolute minimum. Most large automobile companies hold only a few days' supply of parts on hand for safety. Their usual practice is to unload parts from the freight cars in which they have been delivered and to move them directly into the production lines. Obviously this procedure requires a close adjustment of purchasing deliveries to production schedules. A maximum return on invested capital is possible only when plant facilities are operated with a high degree of stability. Products, therefore, are often manufactured and carried in stock. This is particularly true of staple, standard products where the hazard of "guessing" wrong is not great. In times of depression, however, a manufacturer is extremely loath to tie up his working capital in finished-stock inventory when he is constantly pursued by the specter of declining prices and stock obsolescence.

When the raw material is perishable, a manufacturer may be forced to carry a large finished stock unless it can be passed along to his distributors. This is the policy followed by the Campbell Soup Company in connection with its tomato products. When the same or similar parts of an assembled product can be combined in various ways and thus meet a wider range of market requirements, an alternative method is to make parts and to hold them in stores for assembly when a customer's order is actually received. In such a case, finished-stock inventory will be decreased and finished-*parts* stores increased. When products differ widely in dimensions and functions, manufacturing will be carried on for customers' orders only, as in a steel fabricating plant that makes an assortment of tanks, boilers, and hoppers. Here finished-stock inventory will always be at a minimum.

Importance of inventory control. Inventories are an important part of the current assets of a company. They are significant in determining the liquidity and financial soundness of the business, and they play an important role in determining its credit status. It is urgent, therefore, that serious attention be given to keeping them under control, especially in those firms that must carry large inventories and whose material costs are relatively heavy.

Losses through an oversupply of inventory items may arise from price declines, inadequate turnover of working capital, increase in the interest on capital invested, and obsolescence, deterioration, and breakage. The working capital tied up in excessive inventories lies inactive, and the resulting lower capital turnover tends to decrease profits. Furthermore, the interest on the capital in inventories may involve considerable cost. The swift pace of modern competition has increased tremendously the possibility of inventory obsolescence. A barrage of research into new products and new materials has been begun in the past decade. Furthermore, certain materials, such as rubber, foodstuffs, and drugs, deteriorate with age. It is important, therefore, that a company protect itself against losses through change and deterioration.

Losses from an undersupply arise from production delays. Lack of material may delay the starting of a job, interfere with its continuous processing, or delay its assembly into final form. Shop schedules may be upset, delivery promises broken, and customer good will destroyed.

Losses resulting from wastage and misappropriation are encountered when irresponsible operators have easy access to supplies of materials. Parts spoiled by the operator may be hidden in dark and forgotten corners, and replaced from the regular source of supply. Petty thievery of small items with a high intrinsic value may be carried on steadily. These practices do not necessarily spring from the maliciousness of workers. They frequently reflect merely the management's indifference to the job of control, for laxity on the part of the management breeds laxity among workers.

The necessity of controlling inventories is not peculiar to manufacturing industries. Such control is an essential element in the operation of mail-order houses, department stores, wholesale distributors, insurance companies, railroads, and banks—in short, wherever it is necessary to accumulate and hold a supply of any commodity. For example, banks and insurance companies find it necessary to watch their paper, forms, and office supplies. The degree to which control is applied and the exact form in which it is exercised will depend, of course, upon circumstances. In department-store operation, the unit-control method of watching inventories is linked with the setting of stock limits, which, in turn, is related to markup, turnover, buying policies, and sales requirements.

Who controls inventories? The control of inventories should be a joint responsibility of several units of the organization. In this respect it differs from the activities of purchasing, inspection, or maintenance, in which the work to be done can be allocated to a separate individual or department in the organization. Purchasing, production control, and selling all touch the inventory problem at some point, and general operating policies emanating from the major executives have a direct bearing on inventories. A basic necessity, then, for the satisfactory handling of the inventory problem is provision for correlating the work of the several departments concerned.

But with respect to authorizing the use of materials and the maintenance of book records, the work of control can be allocated to certain definite organization units, such as the planning, production-control, order, or stock-records department. The work of keeping the perpetual inventory records is variously assigned to the accounting or planning department, or to a separate department for materials control. It is not good practice to place the control of the book records in the hands of the storekeeper who is in charge of the storeroom.

If control of inventories is to be adequate, materials should be isolated physically, and kept under lock and key. No one should have access to them except a storekeeper responsible for their custody. Such a person takes care of incoming items, stows them in their proper bins, and prepares materials for issuance on requisition. It is important that issuing be done only upon properly authorized requisitions. Failure to assign definite responsibility for storage and issuance means that physical quantities and book records will not check, and the method of control will break down.

The control of inventories necessitates proper physical facilities, that is, a storeroom designed to protect merchandise against deterioration, stealing, and withdrawal by unauthorized persons. Sufficient space must be provided for the proper care and handling of goods. Failure to give close attention to this aspect of control may result in considerable loss through breakage, deterioration, excessive supplies, and unnecessary stoppage of work because of shortages caused by storeroom congestion. The amount of space needed for storage can be determined by an analysis of the quantities of materials or parts to be stored, together with the methods of storing them (see Figures 28 and 29).

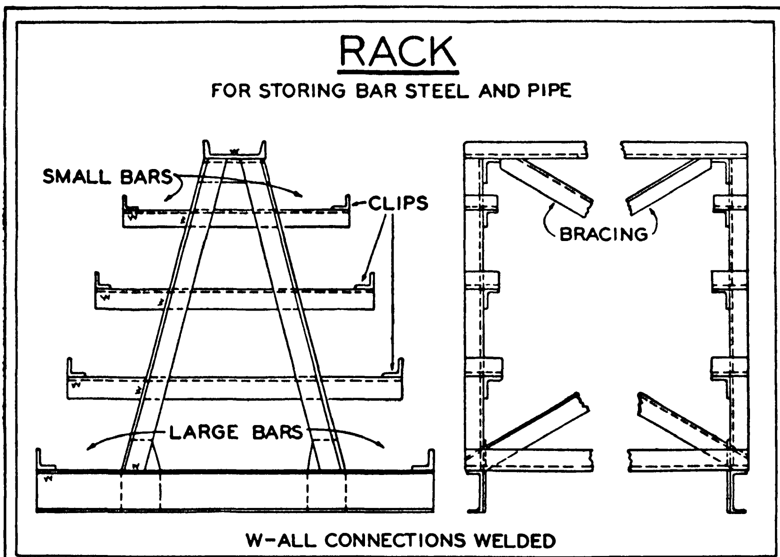


Figure 28.

A more difficult problem is to decide whether there should be a single, centralized storeroom or several storerooms. This decision should be reached only after weighing all the pertinent factors. Quick issuance of materials and minimum handling costs would suggest a series of decentralized storerooms, each located adjacent to the production floor it serves. Yet this arrangement might require the use of high-value production floor space for storage purposes. Moreover, the nature of the material may require special storage facilities. For example, castings are "seasoned" in open storage areas, and coal must be stored so as to prevent spontaneous combustion. Cases are recorded where acids have eaten through a concrete floor a foot thick. Again, fragile products may have to be stored by suspension. In all such cases, the peculiarities required by the material or product must be met even though the cost of handing is thereby increased.

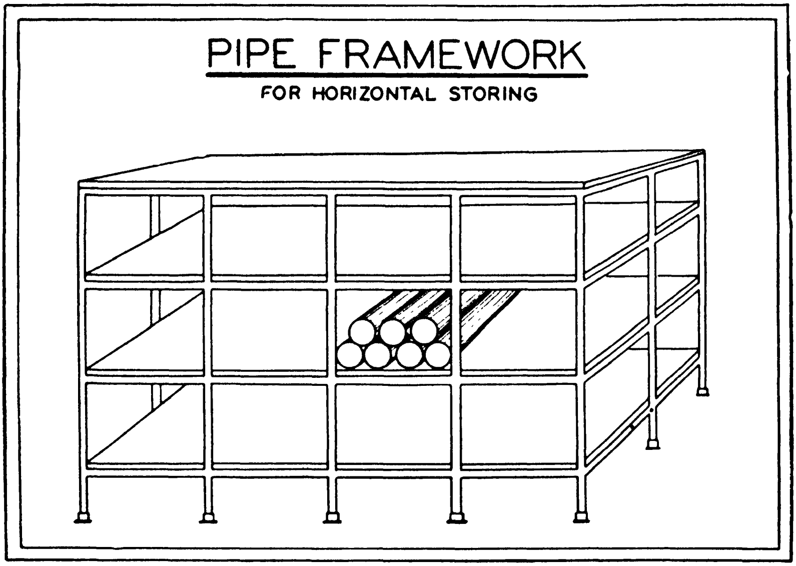


Figure 29.

Storeroom layout. If the storeroom is to render quick service to producing units at the lowest possible cost, all the parts and materials it contains must be readily available. Such accessibility implies that all adequate space is effectively used, and that there is a system of identifying and locating stores items. The proper utilization of storeroom space involves more than providing for the storage of materials. Adequate areas must be provided for the receipt of incoming materials, prior to storing, and for the temporary holding of materials ready for issuance. In addition, main aisles and subaisles must be provided.

With regard to the disposition of materials in the storeroom, parts may be grouped together on the basis of their rapidity of use (the most rapidly moving being placed nearest the point of issue), their similarity in size, or their association in use (that is, all parts of a subassembly in contiguous bins).

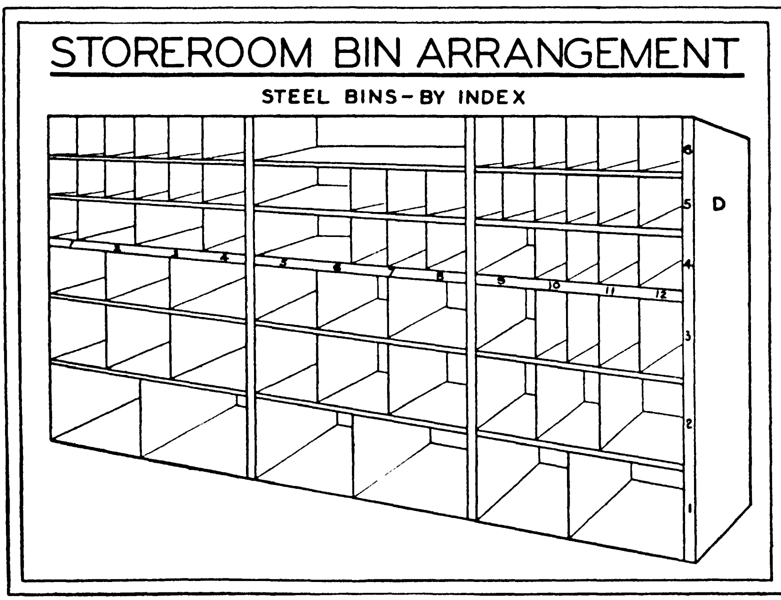


Figure 30.

If the work of the storekeeper and his assistants is to be done as rapidly as possible, a definite system of marking or indexing materials and stores locations is essential (see Figure 30).

Elements of Control

In the control of inventories the major objectives are:

1. To keep the capital invested in inventories as low as is compatible with smooth shop operation and prompt deliveries.

2. To maintain a balanced inventory. This means that the quantities of all items carried in stock are proportioned to usage according to some basic policy of control. The latter will establish the average inventory with which the company operates. For instance, if the policy is to carry regularly a four months' supply of a given class of material, then a three months' supply of one item in that class and a six months' supply of another would represent an unbalanced condition.

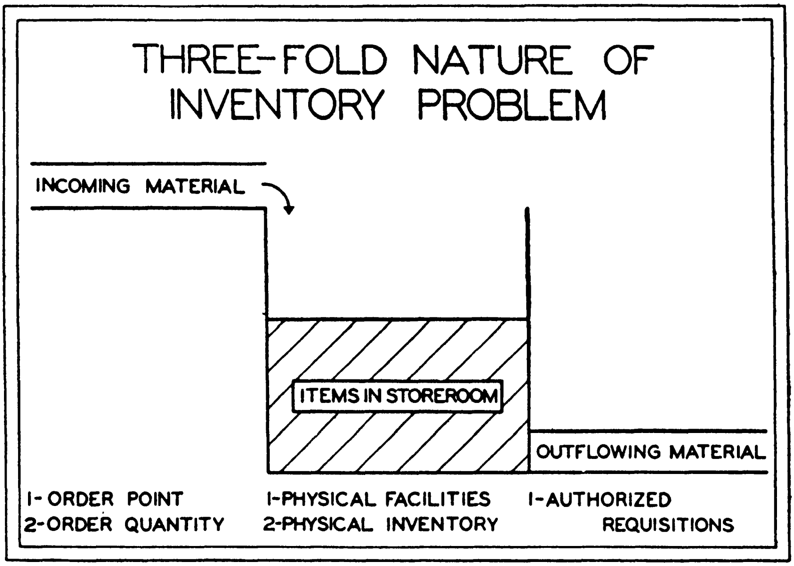


Figure 31.

The attainment of these ends involves the control, first of incoming materials, then of their storage until they are issued, and finally of their withdrawal for production. In connection with incoming material, it is necessary to establish both the proper point at which to reorder, and the quantity to order. The importance of careful storage has already been discussed. The control of the withdrawal of material begins with the proper authorization of its issuance. If it is not expedient to carry out these steps in the storeroom proper, they may be effected through the office by perpetual inventory records. The threefold nature of the problem is pictured in Figure 31.

Determination of when to order. In the absence of adequate methods of control, the question of when to order is all too frequently determined by actual shortage. The wastefulness of this practice condemns it. Depending upon circumstances, the time to order may be decided on by periodic inspection of inventory records or physical supplies and by the use of quota ordering and of "ordering points."

The periodic inspection of supplies or inventory records is an extremely informal method. At stated intervals, an examination of these records may indicate the necessity for reordering. In order that this method may be effective, the person doing this work must know sales requirements. In small plants, with a limited number of items in the inventory account, this method may prove entirely adequate, but as the inventory control problem becomes complicated, periodic inspection tends to become unwieldy and to lead to unbalanced inventories.

Quota ordering is followed in companies where it is necessary to reduce inventories to an absolute minimum. Its success depends entirely upon how adequately production quotas can be established and requirements budgeted. It is most useful where the product is highly standardized and the quantities of materials and parts used bear a constant relation to the finished product. Since the number of parts in a given model remains uniform, automobile manufacturers can follow this method with success, but it would prove unsatisfactory in a company making a great variety of products of complicated design. Specifically, this method operates as follows: The production schedule (derived from the sales estimate) establishes materials and parts requirements. A check upon stock on hand will thus indicate replenishment quantities; and a knowledge of the time necessary for delivery will indicate when orders must be placed.

The ordering point merely indicates a minimum supply below which it becomes necessary to reorder a quantity of that item. When the ordering point is reached, there must remain in stock an amount sufficient to take care of consumption requirements until the amount ordered for replenishment arrives. For instance, if it requires twenty days for delivery and the daily consumption is 50 units, then the ordering point would be set at 1,000. To this amount, a safety factor is usually added. This may be figured either in percentage (10 per cent, for example) or in extra days (two, for example). By either method, the addition of 100 parts would make the ordering point 1,100.

It should be noted that if the ordering point is applied to the physical units in the storeroom, the actual quantities will fall below the ordering point (theoretically, to the safety factor) pending the arrival of the amount ordered. The periodic revision of ordering points is necessary, as the rate of usage and the replenishment time fluctuate. Moreover, if the policy of "making work" for employees in dull seasons is followed, the ordering point principle can still be used, but the factors determining it will necessarily change.

Determining how much to order. There are several bases for the determination of the "ordering quantity." In connection with raw materials and purchased parts, the ordering quantity refers to the amount purchased (the purchase order), and with parts made in the plant, it refers to the quantity to be manufactured (the shop, manufacturing, or production order).

The costs of machine set-up and of placing and following up an order exert pressure upon the management to increase the size of orders. Since these costs are fixed, the cost per unit decreases as the number of units ordered increases. On the other hand, the cost of carrying inventories (storage space, interest on investment, insurance, and so forth) increases directly with the quantity carried in stock. Such expenses, then, exert pressure to reduce the size of orders. Theoretically the quantity at which these two forces balance represents the most economical order size. This quantity, however, may not be entirely satisfactory from a practical point of view because of the risk of a radical change in product design, volume, or price.

Another widely used method of determining order quantities is to estimate them in the light of sales needs and price concessions. The successful application of this technique depends primarily on the judgment and ability of the executive making the decision. In its more formal applications, it may be tied up with an elaborate estimate of future sales and production. In its simpler development, it may depend on rule-of-thumb guides growing out of actual experience.

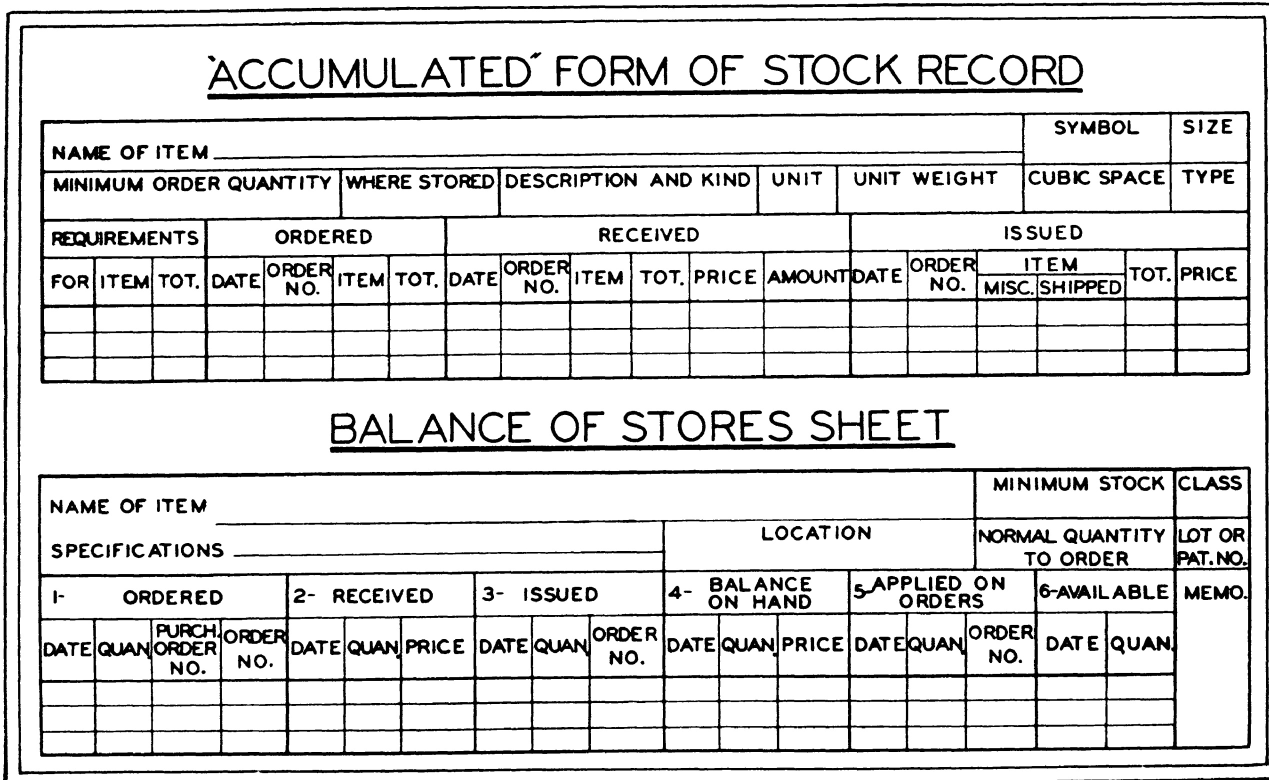
The ordering quantity, arrived at by the use of either of the above methods, may be set up in the control system as the "standard order," which represents the amount to be reordered (purchased or manufactured) each time an order is placed. As with the ordering point, the constant revision of the standard order is necessary if inflated inventories are to be avoided. There is a tendency, however, to recalculate the ordering quantity whenever replacement is necessary, particularly for materials and parts of high value. The standard order is of greatest value during a period of relative business stability and when small-value items are used in large quantities.

Authorizing the use of materials. Materials should be disbursed only upon authorized requisition. This practice is the one employed by many plants. Of 75 companies studied, 57 required the authorization of the use of materials; 13 did not; and 5 required that it be applied to selected materials of high value only. Where materials of low value are used in bulk, a blanket authorization to maintain a constant supply at points of usage may be given to the storeroom. Economy of routine dictates the elimination of unnecessary authorization if control can be maintained without it.

Authorization may be of several types. The usual form used for releasing materials from stores is called the "stores issue" or "stores requisition." When a great many items go out of the storeroom on the same bill of material, a single requisition may cover them all. Or a bill of material may even constitute the authorization. Again, the daily manufacturing schedule may be the authority upon which materials and parts are drawn from stores. In choosing a method, the management should seek effective control and an economical stores routine.

Use of perpetual inventory records. A perpetual inventory is merely a record upon which entries are made representing the additions to and deductions from the supply of an item. It reflects on paper the ebb and flow of materials and parts in the storerooms. Among the records in use, the chief difference in type is between that with cumulative, or running, totals and the balance type (Figure 32). The former merely accumulates a new total after each entry, whereas the latter shows a new balance. Both forms have distinct advantages, and the choice between them depends largely upon what information is desired from the stock record. Naturally the former is faster, and whenever balances are needed they can be easily secured by subtracting the appropriate totals.

The basic information on both types will pertain to the amount of physical goods on hand. In its simplest form, then, the record will show receipts and issues of stock, and, if it is a balance-of-stores record, the balance on hand. In addition to this essential minimum of information, provision may be made for the recording of all sorts of data, and the record may be elaborated into a most intricate form. In some cases the inventory record is used as the source of information in pricing material requisitions for cost purposes. Customers' orders and shipments, or material requirements as derived from production schedules, are frequently entered on the inventory record. Not infrequently, a separate purchase record may be kept to show the amount on order at any time. This information is sometimes included on a type of inventory record known as the "four-column, balance-of-stores card." It con-



"ACCUMULATED" FORM OF STOCK RECORD

NAME OF ITEM					SYMBOL	SIZE
MINIMUM ORDER QUANTITY	WHERE STORED	DESCRIPTION AND KIND	UNIT	UNIT WEIGHT	CUBIC SPACE	TYPE

REQUIREMENTS			ORDERED				RECEIVED						ISSUED					
															ITEM			
FOR	ITEM	TOT.	DATE	ORDER NO.	ITEM	TOT.	DATE	ORDER NO.	ITEM	TOT.	PRICE	AMOUNT	DATE	ORDER NO.	MISC.	SHIPPED	TOT.	PRICE

BALANCE OF STORES SHEET

NAME OF ITEM		MINIMUM STOCK	CLASS
SPECIFICATIONS	LOCATION	NORMAL QUANTITY TO ORDER	LOT OR PAT. NO.

1- ORDERED				2- RECEIVED			3- ISSUED			4- BALANCE ON HAND			5- APPLIED ON ORDERS			6- AVAILABLE		MEMO.
DATE	QUAN.	PURCH. ORDER NO.	ORDER NO.	DATE	QUAN.	PRICE	DATE	QUAN.	ORDER NO.	DATE	QUAN.	PRICE	DATE	QUAN.	ORDER NO.	DATE	QUAN.	

Figure 32.

tains four *balance* columns and therefore represents a perpetual inventory *plus*. The on-order column lessens the likelihood of sending out duplicate shop or purchase orders, and keeps at one point complete information concerning possible receipt of goods in the near future. A reserved and a balance-available column are added to minimize the possibility of running short of material or parts during production. The reserved column is used to apportion on paper (a bookkeeping matter entirely), and in advance of production, material that is sufficient for a given production order. This amount, then, becomes unavailable, and on the balance card is deducted from the available column to show the balance available for subsequent orders.

The ordering point may be used in connection with either the balance-available column or the balance-on-hand column. Ordinarily, where the rate of use is reasonably stable, the ordering point should be applied to the balance on hand; conversely, where the rate varies widely, it should be applied to the balance available. Figure 33 illustrates in detail the use of a balance of stores card. In this illustration, the ordering point is applied to the balance-available column. Columns 1, 4, 5, and 6 are the balance columns, and columns 2 and 3 are merely for journal entries (that is, no balances are kept). Columns 1 plus 4 should always equal columns 5 plus 6; the accuracy of the clerical work can thus be tested at any time.

Sometimes the quantity of material representing the ordering point is physically separated from the other material in the bin, or a distinguishing mark is attached to it. When the storekeeper reaches this quantity, he sends to the proper authority a requisition covering the replacement quantity. The standard order quantity may previously have been entered on this requisition. No clerical work on the part of the storekeeper is entailed, and the balance-of-stores clerk is relieved from watching ordering points. The possibility of posting entries by machine or of using tabulating equipment should

USE OF THE BALANCE OF STORES CARD

NAME OF ITEM 2" COLD ROLLED STEEL				SYMBOL SV2S1R	MIN. STOCK 1500 FT.
SPECIFICATIONS UNIT FOOT				LOCATION A 43	OR. QUAN. 4500 FT.

NO.	1-ORDERED	2-RECEIVED	3-ISSUED	4-BALANCE ON HAND	5-APPLIED ON ORDERS	6-AVAILABLE
1				1/1 2500		2500
2			1/4-847-1100	1400		1400
3	1/5-1450-4500					5900
4					1/10-855-2000	3900
5	2000	1450-2500		1/6 3900		
6			1/18-855-2000	1900	----	
7					1/20-890-2600	1300
8	1/20-1501-6500					5800
9			1/23-890-1000	900	1600	
10	1/25 4500	1450-2000		2900	----	
11		1/27-C.O. 1000		3900		8400

TRANSACTIONS NO.			STORES PROCEDURE; ENTRY POSTED FROM:
1	1/1 ON HAND AND AVAILABLE	2500	
2	1/4 ISSUED TO ORDER 847	1100	STORES REQUISITION MINIMUM REACHED-TIME TO REORDER-PURCHASE REQ'N. SENT TO PUR. DEPT.
3	1/5 ORDERED-P.O. 1450	4500	PURCHASE ORDER
4	1/10 APPORTIONED FOR ORDER 855	2000	STORES REQ'N. FROM PLANNING DEPT. AND RETURNED TO IT
5	1/16 REC. ON ORDER 1450	2500	MATERIAL REC'D-REPORT FROM RECEIVING DEPT. (O.K'D BY INSPECTION DEPT.)
6	1/18 ISSUED ON ORDER 855	2000	STORES REQUISITION
7	1/20 APPORTIONED FOR ORDER 890	2600	STORES REQ'N. FROM PLANNING DEPT. AND RETURNED TO IT. MINIMUM REACHED-TIME TO REORDER
8	1/20 ORDERED P.O. 1501	4500	PURCHASE REQ'N. TO PUR. DEPT.
9	1/23 ISSUED ON ORDER 890	1000	STORES REQUISITION
10	1/25 RECEIVED ON P.O. 1450	2000	MATERIAL REC'D REPORT
11	1/27 ORDER 890 CANCELLED		STORES CREDIT FOR 1000. CANCELLED ORDER FOR 1600

Figure 33.

be thoroughly investigated. Whether requisitions are to be priced for costing purposes must also be determined, so that provision can be made in the routine for the collection and entry of price data on the inventory cards.

Taking physical inventory. The income-tax law of the United States requires that a physical inventory be taken at least once a year. It is also advisable that the perpetual inventory records be checked, since discrepancies between book records and physical quantities on hand cannot usually be avoided. Such a check may be made by closing down the factory while a complete count is made, or by having a small force make a continuous count. The checkers may use any one of these methods: count continuously according to a routine schedule; count when the balance on hand falls to the order point; make "spot" checks; or count the items on hand just before newly received material is put away. Before a physical inventory is taken, it is advisable to have carefully prepared plans and forms that cover the following:

1. Identification of materials counted.
2. Methods of pricing and extending values.
3. Means of checking extensions and tabulating the results.

Inventory valuation. The choice of the method of valuing inventories should be determined by administrative decision, not by custom or imitation. It offers the same opportunity for the exercise of good judgment as other aspects of inventory control and may be of even greater significance to the financial position of the business. Historically, the wide use of "market or cost, whichever is lower" as the basis for inventory valuation was prompted by a desire to show a conservative inventory position on the balance sheet. It is still considered of utmost importance for purposes of financial liquidity and credit to keep inventories in proper relation to other current assets; yet recently, increased attention has been given to the effect of inventory valuation methods on operating profits. The latter are directly affected by the cost of goods sold, which, in turn, is influenced by the value placed upon inventory. A simple illustration should make this relationship clear:

Sales Income		$7,500
Purchases made during year (10,000 units)	$10,000	
less Inventory at close of year (5,000 units)	5,000	
Cost of Goods Sold		5,000
Gross Profit		$2,500

If the closing inventory of 5,000 physical units is priced at 80 cents per unit (the most recent price paid) rather than at the average price of $1.00, the effect on gross profit will be:

Sales Income		$7,500
Purchases made during year (10,000 units)	$10,000	
less Inventory at close of year (5,000 units)	4,000	
Cost of Goods Sold		6,000
Gross Profit		$1,500

Effects on profits and surplus. A variety of methods of inventory valuation are in use. Each has its peculiar effect on operating profits and on the pricing of stores requisitions for accounting purposes. A partial list includes first-in, first-out, sometimes referred to as FIFO; last-in, first-out, commonly called LIFO; normal stock; retail; weighted average; and standard cost. It is not our purpose to explore the implications of all these methods. Inventory valuation is a highly technical field that requires extended study. Yet executive thinking in so significant an area should be informed.

It will be sufficient here to contrast the general profit implications of two currently debated methods: FIFO and LIFO. LIFO charges current operations with current material costs; FIFO charges current operations with material costs incurred in an earlier period. Therefore in a period of rising prices, LIFO will reduce earnings and FIFO increase them. Inventory "profits" are apt to be illusory. LIFO

The difference in the impact upon operating profits and balance sheet position of valuing inventory by FIFO and LIFO when material costs are rising is shown in the following simplified illustration:

TABLE 4

OPERATING STATEMENT

	Pounds		Cost first-in first-out			Cost last in first-out	
Sales 100,000 lbs. @ 26¢				$26,000			$26,000
Beginning Inventory	50,000	9¢	$ 4,500		8¢	$ 4,000	
Purchases	105,000	13¢	13,650		13¢	13,650	
			18,150			17,650	
Closing Inventory	55,000	14¢	7,700				
	50,000				8¢	4,000	
	5,000				10¢	500	
Cost of Sales				10,450			13,150
Gross Profit				15,550			12,850
Selling & Admin. Expenses				8,000			8,000
Net Profit				7,550			4,850

TABLE 5

BALANCE SHEET

LIFO

Assets		Liabilities	
Inventory	$ 4,500	Current Liabilities	$ 4,600
Other Current Assets	8,000	Fixed Liabilities (Mortgage payable)	5,000
Property and Equipment	25,000	Capital and Surplus	28,000
Deferred Charges	100		$37,600
Total	$37,600		

FIFO

Assets		Liabilities	
Inventory	$ 7,700	Current Liabilities	$ 4,600
Other Current Assets	8,000	Fixed Liabilities	5,000
Property and Equipment	25,000	Capital and Surplus	31,200
Deferred Charges	100		$40,800
	$40,800		

protects against profligate dividends when rising prices require an increasingly strong cash position to replace inventories at higher prices. In a period of declining prices, the profit pattern yielded by the two methods is reversed. With respect to the balance sheet, LIFO in a period of rising prices values inventory at less than replacement cost, with a related reduction in the surplus account. In contrast, FIFO gives balance sheet inventory values more nearly approximating replacement cost.

TABLE 6

DATA FOR ILLUSTRATION

Market at beginning of period	10¢	per	lb.
Cost of beginning inventory—first-in, first-out	9¢	"	"
Cost of beginning inventory—last-in, first-out	8¢	"	"
Market at end of period	15¢	"	"
Cost of ending inventory—first-in, first-out	14¢	"	"
Average market price paid for period	13¢	"	"

Analysis of inventory position. Subtle questions that tax executive judgment involve the size of inventories and the internal condition of inventories. The periodic survey of inventory position by using such ratios as *working capital to inventories, receivables to inventories,* or *cost of sales to inventories* indicates tendencies, and may prevent the accumulation of excess inventories as measured against standard or industry ratios. In addition, the use of normal stocks may prevent excessive quantities of materials and products. The internal condition of the inventory account—materials, parts, or finished products—may be determined either by classifying items as *active, slow moving,* and *obsolete,* or by determining the length of time the supply of an item will last at current rate of use. Either method will expose lack of balance and "dead" items, and should lead to selling price changes, sales promotion, repackaging, or other appropriate corrective action.

The control of inventories has a far-reaching sweep that ranges from the minutiae of store-room operation to the larger problems of profit determination. To think of it in terms of mere record keeping is foolhardy.

Questions:

1. How does the Sears Roebuck policy of shipping within twenty-four hours of the receipt of an order affect the control that must be exercised over each item?

2. Increasing attention has been given to the elimination of material wastes in production, particularly in large companies such as the General Electric Company and the Westinghouse Manufacturing Company. What steps should a company take to eliminate such waste?

3. Why is it important to have a *balanced* inventory of materials, parts, or finished stock?

4. Problem: Post the following transactions on Figure 33 and prove the accuracy of your work:

(1)	1/30	Received on P.O. #1501	4,500
(2)	2/1	Apportioned to Order #901	3,000
(3)	2/3	Issued to Order #904	3,900
(4)	2/3	Make the entry that is appropriate at this point.	

Section VI

PRODUCTION PLANNING AND CONTROL

CHAPTER 16

Planning and Control of Factory Operations

THE process of control may be divided into two major parts: the planning of work before it is begun, and the control of work after it has started in order to insure that the plans are carried out.

The planning and control of operations is secured in three ways: by direct personal supervision; by mechanical "pace-setting"; and by "paper work" (that is, by the use of routines and systems). Direct personal supervision is the oldest type, for the early boss depended greatly upon "shirt-sleeve management" and upon personal observation. The fact that an increase in the size of enterprises often prevents the chief executive from seeing everything that goes on makes it imperative for him to create routines and records that will continue whether he is present or not. The use of records, however, by no means eliminates the need for direct personal supervision. A good leader of men can plan the work of his gang in such a way as to take advantage of short cuts and to avoid delays. Good leadership is required to move workers to the spot where they are needed, to assign them to work for which they are best adapted, and to train them to increase the speed and the quality of their work.

Mechanical pace setting is provided by power conveyors. It eliminates many of the tickets and other forms that otherwise would be necessary to bring the materials and tools to the point where they are needed at the proper time. In addition, the steady movement of the conveyor tends to pace the operators along it. If materials are delivered, as needed, to the end of a conveyor, and if the operations are properly balanced, the production control problems are eliminated as long as the conveyor runs smoothly. Like other substitutions of machinery for human beings, the power conveyor depends upon the subdivision of labor. The division of work among many people in such a way that the activities of individuals or groups are limited provides the specialization supporting many other industrial developments. On purely hand operations, such specialization trains workers to develop particular skill, and combined with large-scale manufacturing units, it permits operations to be mechanized. As firms have succeeded in developing a uniform flow of work, they have been able to use conveyors to transfer it from machine to machine. These conveyors link the operators together in a continuous chain. If the moving belt is to function smoothly, it is necessary that the operators work at about the same pace, provided the jobs have been balanced so that there is an even distribution of work. If one operator is slow, the work goes past him undone, unless additional help is placed at that point.

The details involved in "paper work" must be carefully woven into a coordinated plan or system, the tangible evidences of which are the tickets, or forms, passed among those responsible for operations. These tickets contain information directing that certain action be taken, and the completion of such action is usually entered on them. In an economical system they are also used to gather cost and statistical data. The method of planning and control and the system are influenced by the organization, the general operating policies, the methods of manufacture, and the degree of control. Every company should devise methods suited to its own peculiar operating conditions.

Example of simple planning and control. The problems of production planning and control are illustrated by the methods of a medium-sized woodworking plant. It employs 300 to 400 workers, manufactures store fixtures and architectural woodwork, and its entire production consists of special orders from general contractors.

When an inquiry is received, the decision is reached as to whether the delivery requirements of the order can be met. If the decision is in the affirmative, specifications are secured in sufficient detail by the estimating department to prepare a "bid," which is then submitted to the general contractor. If the estimate is satisfactory, a contract or a sales order is received and given a number. A manufacturing order is then written, one copy of which is sent to the drafting department, one to the plant manager, and one to the superintendent. This order constitutes the authorization to begin manufacturing, and contains merely a general description of the product to be made.

The drafting department then prepares detailed drawings or "blueprints" containing complete specifications of the order, a list of all operations necessary to produce each part, and a materials sheet. The materials sheet contains specifications for all lumber and veneer, hardware, glass, and other articles needed. The department also prepares a purchase requisition for each kind of material to be purchased, and forwards it to the purchasing department. The work of the drafting department is the important preliminary step of planning. When its work is completed, exact information is available as to the kind and quantity of material required, the operations to be performed, and the dimensional specifications of the finished parts. The departments involved in the process are as follows:

Drafting	Cabinet
Lumber	Finish
Machining	Freight and Shipping

Erection

At this point planning ceases and control begins, since the foregoing departments must carry out these plans as economically as possible and in time to meet the delivery promise. The purchasing department places its orders and secures promises from the vendors to have the necessary materials on hand at the proper time. When the drawings are finished, they are forwarded to the production manager, who meanwhile has received his copy of the manufacturing order. He, in turn, relays the drawings to the superintendent and the foremen, upon whom rests the immediate responsibility for getting the work done.

As it enters the plant, material is carried to the point of use, and its consumption is reported verbally to the accounting department. The blueprints travel with the work from operation to operation. Securing his information from these prints, the foreman of each department has the task of selecting the machine at which the work will be done, of assigning workmen to the job, and of keeping the work moving. He gives special verbal instructions to the workmen. Responsibility for getting the work finished in time rests upon the foreman, who is watched closely by his superiors, the superintendent and the production manager. Thus, from operation to operation and from department to department, the work moves toward completion and shipment.

It is evident that the methods used by this company are extremely simple, and are based mainly upon personal supervision. The foremen's work, however, is made much more effective by the preliminary planning centered in the drafting department.

Major policies. From the foregoing statement, it should be apparent that production planning and control require the development of policies to guide the executives in making their daily decisions; the development of procedures, routines, and systems to control the multitude of details; and the selection and organization of capable individuals to carry out these policies and procedures.

To determine policies wisely requires a perspective that comes only through experience and understanding. Among the policies affecting the planning and control of factory operations are the following:

1. Whether a given item is made in the plant, or whether it is bought from an outside source.
2. Continuous versus intermittent manufacture.
3. Manufacture for stock or to order.
4. The segregation of repair work from regular production.
5. The size of the manufacturing order.

To make versus to buy. The problem whether a part should be made in the plant or bought from someone else is fundamental not only to expansion policies, but also to production control. This decision may be considered the first step in the control of fabrication, and applies to services—for example, mimeographing, duplicating, nickel plating, and dyeing—as much as to semifinished parts. If parts or services are purchased from the outside, their control involves the purchasing and stores departments, but none of the processing operations except assembly. Consequently the actual control of manufacturing is made easier by purchase, provided deliveries are made on time. In many plants jobs requiring a variety of purchased parts are not started until all the parts are on hand. Orders can be started prior to the arrival of all the materials and parts needed, but the failure of a supplier to make delivery on time disrupts the work and increases the cost. For this reason automobile concerns keep close track of their orders for bodies, tires, and parts, even to the point of placing representatives in the plants of their suppliers.

Continuous versus intermittent manufacture. The decision whether the manufacturing process should be continuous, as in an automobile plant, or intermittent, as in the National Cash Register Company, has a profound influence upon the control of production. If intermittent, the control of production must be worked out through the necessary routines and forms. To be effective, this paper control must be positive in its action by anticipating delays so that they may be avoided, not merely remedied. A substitute for paper control is provided by power conveyors, which are useful in control, provided the operation is continuous. It has already been indicated that mechanical control eliminates many of the tickets and the forms otherwise necessary to bring the materials to the point where they are needed when they are needed. Such control is made possible by continuous processing, because sufficient machines are available to keep each machine "set up" continuously for a single operation. The route of an order and the "batting order" (order of work) for each machine change but little. Moreover, incoming material and parts, such as tires, can be transported directly to the point of use, and since the work flows continuously, there are no troublesome stockrooms into which parts have to be placed for storage until they are needed. The saving in stores records is evident.

To make for stock, or to order. A third question of manufacturing policy affecting control relates to the making for stock and to the time permitted to elapse between the receipt of a customer's order and its shipment. If a company makes for stock, it can ship immediately if it controls its inventory effectively. In spite of the obvious risks, manufacture for stock simplifies the control of work in process. Such orders tend to be standard, to follow a set route, and to use materials of uniform size and kind. Consequently, repetition makes for simplicity of control. For example, a bill of material may be used time after time for requisitioning materials from the storeroom, and the foremen and operators become so used to the path followed by these orders that route sheets become unnecessary.

In contrast is the policy of working to customer's order. Here the detail is greater than in the case of manufacture for stock. Each order must have its own bill of material and its own route sheet. It must be juggled into a place in the master schedule so that it may be shipped when promised, and it must be assigned a place in the "batting order" for each machine. In addition, this method usually requires special shop drawings that must, for the sake of safety, be approved by the customer before the materials are purchased for the job. In short, these customers' orders require many times as much paper work and executive attention as do jobs made for stock.

Segregation of repair work. Nearly all companies making assembled articles must do repair work. Often such repairs are made in the customer's establishment, as in the case of power-house equipment. Sometimes, such work as automobile repair is done in service stations. But articles like watches and scientific instruments are returned to the factory. In such instances the decision must be made whether they should be run through the regular production processes or be repaired in a separate division. The latter policy is followed by manufacturers of automobiles and diesel locomotives for correcting the "errors and defects" brought to light by final inspection.

Size of manufacturing order. The optimum size of a manufacturing order depends upon the economy with which it can be produced and upon the current rate of sale for the product in question. If a company produces only to the customer's order, it may combine several sales orders into one manufacturing order, and thus secure a more satisfactory lot size. If the enterprise makes for stock, it can work out a formula that will reveal the particular quantity it should manufacture in order to balance the cost of making too much against the cost of making too little.

In general, there are three possible solutions to this problem: the empirical, or rule-of-thumb, method; the use of an abstract formula sufficiently general to fit any business; and the use of a formula developed especially for the particular plant. Only the last of these will be discussed.

In the preparation and use of a formula developed for a given plant, it is important to take into account all the pertinent factors and to develop a method of application sufficiently simple to be used by clerks who are not mathematicians.

The development of a formula from the company's own data requires a consideration of the following factors:

1. The probable sales demand for a given period.
2. The costs, such as set-up cost, that are constant for each lot regardless of its size.
3. The manufacturing cost, which may often be ignored.
4. The carrying charge, which includes the insurance carried upon the goods stored, and the interest upon the capital invested in them.
5. The storage charge, which covers the "rental" of space required for storage. If the space is actually rented, this charge should always be included; if the space is owned, the rental charge should be included unless the space used would be unavoidably idle if not utilized for storing.

The foregoing factors may be incorporated in a formula that expresses their relationship. A detailed discussion of a method sufficiently simple for practical use is given by E. L. Grant in his *Principles of Engineering Economy.*

For simplicity of application the formula can be worked out for sales requirements for such periods as three months, six months, nine months, and a year. The result of applying one company's formula to one of its products is shown below:

Costs of Product *A* Affected by Size of Lot

	If Batch Equals 3 Months' Stock	*If Batch Equals 6 Months' Stock*	*If Batch Equals 9 Months' Stock*	*If Batch Equals 12 Months' Stock*
Preparation Cost	$ 55.39	$ 27.69	$ 17.84	$ 13.85
Manufacturing Cost ..	64.12	48.04	37.29	31.98
Storage Cost	9.00	18.00	27.00	36.00
Carrying Cost	21.03	42.06	63.09	84.12
Total Per Year	$149.54	$135.79	$145.22	$165.95

Most economical size of lot for this item is 6 months' stock.

Functions of planning and control. Planning, which has already been mentioned as a major step in administering operations, is of course an essential part of managing any phase of business. Planning is so pervasive that the use of the term cannot properly be limited to production. The idea of planning has been discussed earlier in connection with product design. The tangible results of this planning in most manufacturing concerns is the bill of material or, in the case of standard products, the materials budget. The planning of how much material to buy is a step in inventory control. The planning of the cost of new products is ordinarily termed "estimating," especially in companies manufacturing to customer's order.

Authorization of production. No work should be undertaken in the factory without proper authorization from a recognized source. This authorization is conveyed by the manufacturing (or production) order. In a company making to customer's order, it may correspond to a single sales order, but in shops where orders are received frequently and where delivery promises permit, it may represent a group of sales orders combined to secure the economies of long runs. If manufacturing is for stock, every effort will be made to release quantities that represent economical lots. The manufacturing order may also originate from a request of the balance-of-stores clerk, if a stock item has dropped to the ordering point. The source of authorization may be either the sales department or the production department, but preferably a responsible executive in the latter.

Routing. *Routing is the function that determines in advance what operations are to be performed and where (that is, at what machines or workplaces) the work is to be done.* It defines the path that an order will follow through the factory or office. When applied to the management of salesmen, the route list indicates the customers the salesman is to visit and the sequence in which he is to call on them. In a factory, a route sheet is a list of the operations to be performed, arranged in their proper sequence, as shown in Figure 34. Opposite each operation is shown the machine at which it is to be done.

The detailed work of routing consists of four steps:

1. The determination of parts and materials to be purchased, as dictated by the basic operating policies; of stock items on hand; and of parts to be manufactured.

ROUTE SHEET

SYMBOL P 2½ H I B	DRAWING NO. 50936	DATE 4-7-23	WRITTEN BY J.M.C.

DESCRIPTION BACK 2½" HEAVY DUTY PADLOCK

QUANTITY IN LOT 20,000 MAT'L SV .083 X 2 15/16 S 4 R

TIME PER PCE. HRS.	PREP. HRS.	OPERATION NO.	OPERATION DESCRIPTION	MACH. NO.	MOVE	OPERATION	FIRST INSP.	FINAL INSP.
			MAT'L APPORTIONED AND ON HAND					
		1	BLANK AND FILE	PA 17				
		2	FORM AND STAMP	PD 17				
			DELIVERED TO R. S.					
		3	PIERCE	PD 9				
		4	STRADDLE MILL SHACKLEWAY	MP5				
		5	RUMBLE IN SAWDUST	T 2				
		6	GRIND BURRS ON TOP	G 7				
			NOTE—COLUMNS FOR PROGRESS FOLLOW-UP →					
		13	EBONY BLACK RUSTLESS FINISH DELIVER TO P. S.	XII				

Adapted from Lansburgh, R. H., "Industrial Management."

Figure 34.

2. The determination of the sequence of operations on parts and assemblies, as well as of class of machine, jigs, fixtures, and tools necessary. Wherever possible it is desirable to indicate alternate machines upon which each operation can be performed. Such information is valuable in meeting emergencies. In some cases, orders may be routed to the specific machine, particularly where there are appreciable cost differentials, or where a certain machine represents a "bottleneck" operation.

3. The determination of the sequence in which parts and subassemblies are to be completed. This is necessary in order that parts may be brought together as needed in manufacture. Complete information concerning the time in which each operation can be performed is therefore indispensable to the work of the route clerk. The route clerk should be a practical shop man, who possesses a full knowledge of machine rates and capacities.

4. The determination of the lot size or quantity to manufacture.

In plants producing standard articles, all the details of routing are performed far in advance of actual production. Figure 35 represents a typical manufacturing route sheet, called by the Western Electric Company a manufacturing layout, prepared shortly after drawings and specifications are released. Such data are released well in advance of production. If the intermittent method of manufacture is used, the day-to-day problem of routing is relatively simple. This information, once prepared, is duplicated, filed away in the production or planning department, and used over and over again in the control of repeat orders. In contrast, if large-scale manufacture is carried on, the routing information is the basis for determining the layout of machines and equipment. With a knowledge of the rate of production and capacity of equipment, the proper balance for a definite load of work can be determined. In addition, these plants are often highly conveyorized. In such circumstances routing is of little significance until a change of model requires that the layout be revamped. In large-scale production of assembled articles, the simplicity of the routing problem resembles that in a truly continuous industry, such as worsted yarn spinning, sugar refining, or flour milling. Since the sequence of operations is prescribed by the relatively simple nature of the process, routing is of little importance, and no elaborate mechanisms are warranted. The problem of control centers largely on the availability of equipment, which, in turn, depends upon the scheduling of the load of work.

In contrast, a company manufacturing to customer's order a specialty or a diversified line must carry on the details of

MANUFACTURING LAYOUT RECORD

(ROUTE SHEET)

DEPT	OPERATION	TOOLS & SPECIFICATIONS	MACHINES
338	PREF.(4).093 HOLES.AND BLANK	P&D C-16374	#3 BLISS
	TUMBLE	SAWDUST AND PUMICE	TUMB. BBL.
	FLATTEN	P&D C-57827	#19 BLISS
641-2	INSPECT		
263	COUNT		
333	BORE 53/64 HOLE	JIG C-57827 USE GAUGE PIN ASSEMBLY DET.#16 GAUGE PL.DET.#2 POS. H. DET.#7 IN POSITION "A" AND GAUGE PIN, DET.#9 IN POSITION 1 AND 8. COMB. C'BORE AND C'SINK TOOL C-48318, GRD. TO SUIT	1 SP. B.D.P.
	GRIND OFF CBORING BURR IN COUNTERSINK(4)HOLES	DISC C-72199 SPEC. GR. DRILL	DISC MOTOR 1 SP. B.D.P.
	REMOVE GRINDING BURR IN 53/64 HOLE	SCRAPER	BENCH
642-3	INSPECT		
251	COUNT		
343	ACID DIP	SPEC.50029, METHOD#9-B	
	DRY	SPEC.50032, METHOD#1-A	
643-1	INSPECT		
255	COUNT		
230	STORE		

DELIVER IN CONTAINER NO. 782 UNLESS OTHERWISE SPECIFIED

ISSUE 2-19-26 REPL. ISSUE 12-28-25	SHEET NO. SHEETS INSET	NAME OF PART FACE PLATE, DRWG. P-88235 APPARATUS MISC. SIGNALS

FROM STORE	QUANTITY PER 1000 PARTS	RAW MAT'L NUMBERS	PART NO. OR DESCRIPTION OF STOCK	DELIVER TO DEPT.
239	35#		1064"X1-9/32"X72" GRADE "A" HALF HARD BRASS. SHEET, SPEC. 57504 53 PCS. PER SHEET 1-9/32"X 72" ON 1-11/32" CENTERS. 18.87-SHEETS 1-9/32"X 72" PER M POS.	338

ISSUED BY PLANNING DIV. 6430 DO NOT REMOVE FROM BINDER

NOTE SEQUENCE OF OPERATIONS, TOOLS, AND TYPE OF MACHINE

Figure 35.

routing after the receipt of each order. One of the difficulties in such cases arises from the pressure under which this work must be done. The nature of the product requires general-purpose machinery, and the routing mechanisms, particularly if under centralized control, may be justifiably elaborate. Figure 34 is a typical route sheet used in planning the sequence of operations on parts; a modification may be used for subassemblies.

Preparation of forms for control of work. Based on the information prepared in the process of routing, the necessary control forms or dispatch tickets are made out for later use by the dispatcher or foreman in executing the plans previously developed. The number used and the information placed on each form depend upon the nature of the particular business and upon the extent of control exercised over the elements of production.

At one extreme lies the method of control devised by Frederick W. Taylor for use in machine shops making diversified products—a method by which every detail of shop operation is controlled separately. For example, control is secured by the use of a tag bearing the lot number and information to identify the job through the entire production process; a move ticket to control the transportation of material from one operation to the next; a time ticket to control the machine operator and to collect pay-roll and cost information; an inspection ticket to control the first and final inspection of a lot of material; operation tickets and a bulletin board to indicate the order of work for each machine and the issue of tools, drawings, and instruction sheets to machine operators; and a stores issue to procure materials and parts from the storeroom. In a highly complicated method of manufacture with any appreciable volume of work, such a method becomes unwieldy and inflexible. At the other extreme is the simple procedure whereby centralized control is shared with the foreman. An identification tag, indicating the sequence of operations and the machine at which each is to be performed, is attached to the lot of material. One other form, a time ticket, is used to control labor, to prepare the payroll, and to secure the direct labor costs on the order. It is up to the foreman to see that work moves along between operations, that inspection is made where designated, and that the operator receives proper tools and instructions.

The nature of the business influences the simplicity of the procedure followed. In the manufacture of circuit breakers, a great many forms are used; in an automobile plant, the number is reduced to a minimum. In hosiery mills and in shoe and shirt factories, where operations are short and their sequence is standardized, strip tickets are often used to control whole series of operations (see Figure 36). In such cases, tickets bearing serial numbers are attached to each batch of material before manufacture begins. Each ticket carries a coupon for each operation in the series, and each is detached by the worker after completing his operation. Part of each ticket may go to his supervisor for transmittal to the planning department, and part may be retained for assistance in checking his pay. After they are prepared, all forms are gathered together and held in a route file until the job is started.

It is extremely important, particularly in intermittent manufacture, that all jobs going through the factory bear clean and legible marks for proper identification. These may appear on a tag, or they may be painted, stamped, or printed on the part.

Scheduling. *Scheduling involves planning when the work will be performed.* The technical meaning of a schedule is a list. The function may be divided into the development of the master schedule, and of the "batting order" (that is, order of work). The object of the first is to indicate when delivery can be promised to a customer with due consideration to the load already scheduled for key operations. In shops manufacturing to special order, the master schedule consists of a list of customers' orders arranged by delivery dates; in plants manufacturing a variety of products for stock, it usually con-

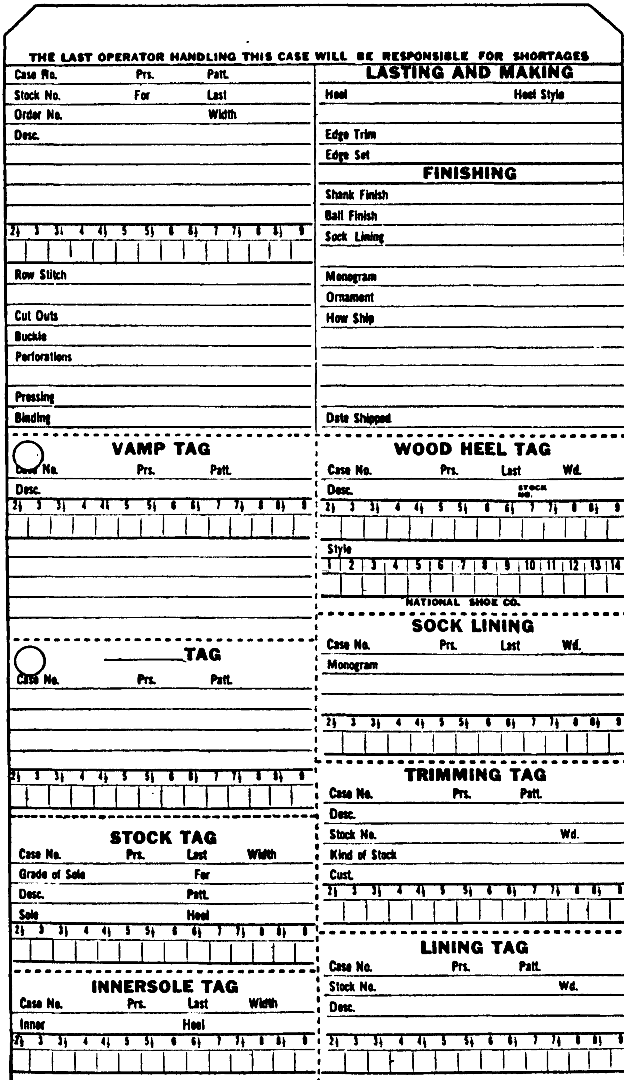


Figure 36. Strip Operation Ticket for a Shoe Company.

sists of the estimated amount of production of each class of product for a definite future period. The translation of these general requirements into specific sizes and weights of product is assigned to the production department, which decides each case by watching the rate of sales and the status of stock inventories. For instance, the Walworth Company, manufacturing plumbing supplies, estimates production requirements for each class of product by weight. On the other hand, where a limited number of standard products is made, the master schedule may call for a definite number of specific products. This is typical of most automobile concerns. In a great many plants, orders consist of special, regular, stock, and repair jobs. The master schedule must, of course, provide for all types of orders so that plant facilities are used most advantageously. In addition, orders may be grouped by classes, and a definite priority be assigned to each class in order to expedite the flow of work. Thus, in a plant manufacturing to customer's order, this classification may be: rush, regular, repair, and stock; whereas in a plant manufacturing for stock, it may be: rush, stock, repair, and special. Since rush orders are a curse to any shop, a great effort should be made to eliminate them.

In manufacturing for stock it is possible in normal times to forecast sales requirements for months ahead, and production schedules may level off sales irregularities. Typical of such forecasting is that done in a large automobile company, as follows:

1. Broad plans are laid for the entire season.

2. Tentative quarterly sales schedules are estimated. On the basis of these forecasts blanket orders for automobile purchases are issued to the purchasing department.

3. Definite fabricating orders for the first thirty days of the quarter are issued to outside vendors.

4. On the twenty-fifth of each month, the shipping schedule for the first ten days of the following month is issued.

5. Finally, a daily shipping schedule containing the complete detail of finish, color, wheels, and other items, is given three days in advance.

In such a program no effort is made to operate the factory on a level basis; sole emphasis is placed upon a close tie-up with sales.

In the Western Electric Company an estimate of probable manufacturing activity by major lines of product is compiled semiannually. The specific production authorizations for the manufacture of each major type of apparatus are issued monthly.

Whether manufacturing is done for stock or special order, it is extremely important that the work of the sales and production departments be closely coordinated. With special-order manufacture the sales department should be kept advised concerning shop loads or unused capacity, so that in its negotiations with prospective customers it will not commit the company to absurd delivery promises. Moreover, no final delivery dates should be set by the sales department without consulting production executives, because the ability to make delivery depends on processing time and the availability of equipment. In manufacturing for stock, the liaison between sales and production is even more important. Changes in style and design of products may occur rapidly. These shifts must be reflected in shop schedules if earning power is to be sustained; thus, flexibility of the master schedule is essential to successful operation. In the Plymouth automobile organization, a premium is placed on the close correlation of sales and production. The daily shipping schedule is built up shortly before actual assembly, and is based on estimates made by the sales department and delivered to the dispatcher in the shop by a special sales-contact man.

A related problem is to plan day by day the sequence in which orders are to be worked on at each machine (or in each department). This phase of scheduling helps the foremen to decide what is to be done next when assigning jobs to their employees. It is sometimes referred to as the "order of work"; in baseball parlance it is the "batting order" of jobs at each machine.

The length of time of each operation, the capacity of equipment, and the load ahead are vital factors in determining the "batting order"; these are usually expressed in terms of machine hours. Figure 37 is a form used in Western Electric for determining machine loads. The starting date of an order is determined by working back from the promised delivery date, and by calculating how quickly parts and assemblies can be completed in view of the load of work ahead of the shop. In large organizations, departmental due dates are often established. Thus each department becomes a little factory, the foreman of which is given a due date comparable with the delivery dates promised to customers. The purpose of the order of work is to maneuver jobs through the process of

MACHINE LOADS

DEPT. 6339						OPERATING CONDITIONS			MONTH SEPT	
ITEM NUMBER	DATE RECEIVED	PIECE PART NO. OR ORDER NUMBER	MANUFACTURING CLASS NO.	DATE PROMISED	DATE COMPLETED	MACHINE CAPACITY IN HOURS				
						4 WK.	8476	(A)	4488	(A)
						5 WK.	10528		5236	
						TYPE OF MACHINE				
						ALTERNATE MACHINES			#5 #21	
							BENCH		#76 BLISS	
1	7-2	87530	021	9-20			200		140	
							200		140	
2	7-29	93490	060	9-22			705		740	
							905		880	
3	7-29	94594	021	9-21			400		1010	
							1305	(B)	1890	(B)

Note: Machine capacity in hours for the month (A) less cumulative hours assigned (B) equals unused or available capacity for each machine or work center.

Figure 37.

manufacture to meet departmental due dates, or the delivery date promised to the customer.

In continuous industries, such as brick manufacture and automobile production, the operation of the order of work is of negligible importance. In such cases the problem of utilizing equipment is primarily a matter of feeding a sufficient supply of raw materials into the beginning of the process, and of introducing additional parts or materials when needed. The flow of work to each machine must necessarily follow the layout of equipment. In a plant using general-purpose machines, however, the problem of utilizing equipment is an outstanding one, and the determination of the order of work is correspondingly important. The order of work must bear the brunt of sudden changes in the status of lots in the shop, arising from the breakdown of equipment and similar delays. In connection with the operation of the order of work, numerous types of bulletin boards, graphic controls, and progress and load charts have been used to advantage.

Figure 38. Dispatch Cage. Air Circuit Breaker Control Cage in the Philadelphia plant of the General Electric Company.

Dispatching. On the dividing line between production planning and control is the dispatching function. This term designates the detail job of actually putting the plans into effect, that is, handing out the various orders and tickets that have been prepared in advance, and otherwise attending to the work of getting to the workman *when he needs them,* the materials, tools, instruction sheets, and shop drawings. Control tickets are taken from the route file and issued to the proper persons for appropriate action. From the operating departments the dispatcher receives the first reports on progress and accomplishment.

The dispatcher is in the important position of having to catch all delays and shop troubles, to take care of them by making adjustments in the order of work of other machines as quickly as possible, and to keep the work moving with a minimum of disturbance. For this reason he must have quick and easy access to all parts of the shop. Accessibility may be provided by adequate messenger service, or by such ingenious devices as pneumatic tubes, the telautograph, and the teletype. The exact nature of the dispatching function depends upon the routing and scheduling procedures and the production organization. From the nature of his work it follows that the dispatcher must be a practical shop man, well-informed on machine capacities, machine loads, and processing time.

Not only is dispatching the connecting link between planning and the actual work, but if properly handled, it eliminates the costly delays between the completion of one job by a worker and the starting of the next one. It is so closely allied with the operation of the order of work that it is usually convenient for the same person to take care of both functions.

Follow-up. Still another function that belongs to control rather than to planning is the follow-up of the progress of orders. For convenience, the route sheets used in indicating the sequence of operations may contain progress columns in which appropriate checks can be made (see Figure 34). The follow-up methods outlined below are designed to discover deviations from planned results. They should form the basis of immediate corrective action, whether the reasons lie in unstandard operating conditions, inefficient operators, or inadequate planning and control of shop activities. In plants manufacturing for customer's order, the order is often identified throughout the process so that it may be followed up in detail. Where manufacturing is done for stock, the balance between estimated and actual sales, production orders, and inventories is of more importance in interpreting shop conditions than is the status of individual jobs. The follow-up work under modern methods of planned production control is a tremendous advance over the type of follow-up represented by stock chasers who swarmed over the shop searching for "lost" orders. Some of the methods used are the following:

1. There may be an immediate follow-up as to the progress of individual jobs in order to show at any moment their exact status in the shop.
2. In large-scale, continuous manufacture of a standard product, there may be hourly or daily reports of quantities finished after each operation or after selected key operations.
3. The status of shop conditions in general may be pictured by presenting daily or weekly reports showing the orders completed, work in process, the extent and causes of shop delays, the amount of spoilage and material waste, and the status of inventories.[1]

Precision of control. One of the most difficult questions of managerial judgment is the degree of precision that should be sought. The cost of control is increased by the number of items manufactured and of points at which control is exerted. For example, if operating costs on several machines were identical, the routing to individual ones would be uneconomical. Attempts to secure too complete control may indicate lack of judgment and managerial experience. The control should be only as precise as will be advantageous. Often results that are "good enough" can be obtained by controlling the key operations and the costly parts or products. This question of precision affects the refinement of the routing

[1] The Gantt progress chart, which permits charting the three variables—time, planned production, and actual production—may be applied to these situations.

(that is, whether to departments, or to machines within departments), the detail to which the scheduling is carried, and the closeness (in time) with which the progress of orders is followed up.

Progress records and reports are of many kinds, such as Gantt charts, visible books, and bulletin boards. The mechanism is important here only to emphasize the need for adapting it to the actual conditions. The length of time permitted to elapse between the completion of a given step in the process and its recording on a progress report should depend upon the possible losses resulting from delay. In some plants the progress is known almost instantaneously (that is, by telephoning whenever a department is behind schedule); in others, the posting of progress within twenty-four hours is adequate; and in still others, weekly reports are deemed sufficient.

Organization. The control of production must finally rest upon a group of individuals whose duty it is to meet production schedules and to carry out the basic policies and practices previously discussed. It will perhaps clarify the treatment to trace the evolution of production control organization. In the older order of industry, no distinction was made between planning and control. The problem of getting work done rested directly on the shoulders of the superintendent and the foreman of the shop (the "line," or operating, organization). Sales orders with their bills of materials and specifications attached were turned over to the factory office. Delivery promises to customers were made with little or no relation to the load of work in the shop. The operations to be performed and the necessary tools were usually determined by the foreman, in consultation with the machine operator, or were left entirely to the latter's judgment. Work was pushed through the shop in a haphazard manner, and, as might be expected, attention was centered upon the orders of those customers who demanded delivery most urgently. Delivery promises were broken habitually.

The costliness of getting out production under these conditions was excessive. As a result, additional methods were developed to aid the factory office in the control of work in process. This form of control was sometimes referred to as "simple production department control." An effort was made to decrease the number of rush orders by the use of a master schedule, which, in turn, required the development of a manufacturing order system to authorize the starting of work. These orders represented either customers' orders or profitable manufacturing quantities. In addition, the simple production department usually provided for a progress report, which served as a daily or weekly check on shop orders. This report showed the amount of incompleted work, the capacity of departments to absorb further orders, and the shortage of parts required. A force of stock chasers was usually provided to prod the foremen into action on delayed orders. Such development of control was a definite advance from the chaotic situation described previously. A small measure of planning was evident in the use of the master schedule and load chart, but primary emphasis was still placed upon checking up *after* delays occurred. It was essentially a method of "drift and check up."

Once the distinction between planning and execution became clearly understood, a radical advance was made in organization and in methods of control. In both of the foregoing situations, the "line," or operating, organization was in full control, but there was no provision for systematically planning the work before it was started. After the distinction had been clearly drawn, however, functional specialists were introduced into the shop. At first they took over from the foreman all activities involved in planning (that is, all routing, scheduling, dispatching, and follow-up of work). This stage in the evolution of control represented the complete functionalization of planning, and these specialists soon constituted the planning department, a term still widely used. However, titles are all too frequently misleading, and many so-called planning departments have little if anything to do with the direct control of the shop, for effective planning may be done in the superintendent's office quite as often as in a planning department. This functionalization was intended to exert positive control in an area where the rule-of-thumb methods of the superintendent and his foremen permitted unprepared-for emergencies to arise. In practice, the efficiencies resulting from this step depend upon whether the staff specialists in the production planning department have the innate ability, the experience, and the necessary aids (such as time-study data) to direct the work more effectively than the shop supervisors. In any given firm, the proper decision upon this point depends upon the stage reached in its management development, and the known abilities of the men involved.

TABLE 7

PRODUCTION CONTROL ACTIVITIES

Those dealing with the order:
- Authorization of production.
- Determination of the sequence of operations and the class of machines to be used.
- Follow-up of progress of jobs.
- Determination of the order of work for each department.

Those dealing with the material:
- Authorization of the use of material.
- Internal transportation.
- Ordering inspection to be done.

Those dealing with the machine:
- Selection of the specific machine or workplace.
- Determination of the order of work for each machine and workplace.
- Getting tools to the point of use.

Those dealing with the man:
- Selection of the operator for each job.
- Getting instructions and drawings to the operator.

In order to understand the problem of control, the activities that must be dealt with in the shop are listed in Table 7. These activities vary, of course, with the kind of enterprise. Not in every case will these elements assume the same degree of importance, and in establishing control it is always advisable to adapt the technique to the peculiar conditions faced by the company. For example, in a tapestry mill the sequence of operations and the class of machine are the same for all orders, and the choice of these factors is not a problem of production planning. Similarly, in an automobile plant, once the conveyor lines have been set up and the machines moved into place, the determination of the order of work for each machine requires no attention.

In practice, executives are faced with two organization problems in connection with controlling production: how far to functionalize the activity and how far to centralize it.

At the present time three types of arrangement are in use:

1. Complete functionalization.
2. Complete control by the "line" organization (that is, the superintendent and the foremen).
3. A combination of the above practices, under which the work is divided between a functional group and the "line" executives.

Complete functionalization. As pointed out previously, when all the functions of planning are assigned to a special group of individuals, the control of production is said to be completely functionalized, and only under such a situation is centralization found. Such a planning group may operate in at least four ways, depending largely on the size of the company:

1. Complete centralization of all planning functions (routing, scheduling, and dispatching) for the whole shop. This method is ordinarily used in small organizations, and is followed by the Tabor Manufacturing Company, where F. W. Taylor applied a large part of his contribution to management practices. It is also used by the New England Butt Company, manufacturers of braiding machinery, and to some extent by the Electric Service Supplies Company, in Philadelphia.
2. Completely centralized routing and scheduling, with decentralized dispatching. Dispatch booths, located in all departments, are connected with the central group by messen-

ger service or by pneumatic tubes, as in the plant of the Proctor and Schwartz Company, in Philadelphia.

3. Centralized routing, scheduling, and dispatching of work as it flows between departments; and, in addition, decentralized planning units located in each individual department. This practice is used in very large plants, such as the Westinghouse Electric Corporation, at Lester, Pennsylvania, and the Budd Manufacturing Company, in Philadelphia.

4. Decentralized planning and control. In each department there is a fully functionalized planning unit, operating in its own area only. This plan is followed at the Philadelphia plant of the General Electric Company, and is found only in very large plants.

Complete control by the "line" organization. At the opposite extreme to complete functionalization is the method of making the "line" organization completely responsible for the planning and control of production. This practice suggests a state of management previously condemned; but safeguarded by many of the devices of planning, it may prove effective. It has the advantages of speedy action and of flexibility. An example of "line" control is found in the Philadelphia plant of the National Biscuit Company, in which a program committee, consisting of the plant manager, superintendent of the warehouse, superintendent of the baking department, and foreman of the icing department, work out the production schedule two days in advance of manufacture. The schedule is then turned over to the "line" foremen, who must see that it is met. In the New York Shipbuilding Corporation, the order and the engineering departments, working back from the final delivery date, establish "due dates" for each department affected. These dates, with detailed drawings for all parts of the ship, are turned over to the "line" organization for execution.

Combination of the previous practices. In perhaps a majority of companies, control is divided between functional specialists and "line" executives, but the best results are secured only with "line" executives of a high type. It is certain that, insofar as current practice is concerned, the foremen, the superintendent, and other operating executives have not been eliminated from the control of production. Functionalization has been used to the greatest extent in those

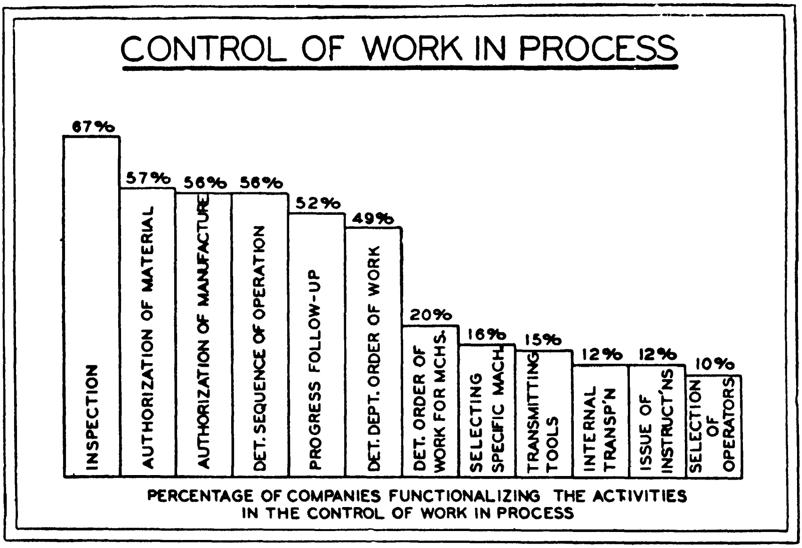


Figure 39.

activities done in advance of actual manufacturing operations, and in the performance of which specialized skill is demanded.

Figure 39 illustrates two interesting points.

1. The "line" executive plays an important role in production activities, even in such specialized fields as inspection.
2. In those activities closely associated in time with the actual production operations, the "line" plays the dominant role. For example, determining the order of work for the machine and workplace, selecting the operator, and getting instructions, material, and tools to him are all performed shortly before the operation starts. Emergencies occurring in

connection with these activities require immediate action, and flexibility is of the utmost importance. In six activities, less than 20 per cent of the companies resorted to functionalization, but in the remaining ones at least 49 per cent of them employed functional units.

A Case of Production Control—Electric Service Manufacturing Company

The Electric Service Manufacturing Company, of Philadelphia, makes a wide variety of electrical appliances, such as floodlights, locomotive headlights, and lightning arresters. Its sales consist both of standard and catalogue items and of special orders.

When an item is adopted for the catalogue, the preliminary planning is done before any orders are received. First of all the drafting room prepares detailed drawings and bills of material for each product as soon as the development of the product is finished. At the same time, a "traveler" is made up for each part. It consists of the routing or sequence of operations, indicates the exact machines needed to produce the article, and shows the standard time for each operation, as determined by the time-study department. The bills of material and the "travelers" are then duplicated, and a supply is forwarded to the planning department, where time tickets are prepared in duplicate for each operation, together with a stores requisition for each item of raw material. All forms are then filed in the department.

When a sales order for one of these standard products is received, it passes through an order department, which rewrites the order in shop terms. The shop order is then passed into the planning department, to be checked against the finished stock record. If a sufficient supply is on hand, the order is then sent to the finished-stock room, where the product is taken from stock, packed, and shipped.

If parts must be made and assembled to fill an order, a delivery date is set, and the customer is informed accordingly. If the latter is satisfied, production is started. The bills of material, the "traveler," and the time tickets for these parts are pulled from the file in the planning department, and lot numbers and identifying information are entered. These forms are ultimately turned over to the dispatcher at the dispatch board, as pictured in Figure 40. This board contains a number for each machine in the shop, and under each machine number there are three slots for time tickets. The ticket for the job then on the machine is placed in the top slot; in the second slot, the tickets for other jobs are held according to the planned order of work. The third slot is used merely as a file for inactive tickets. The control board is connected with each department by pneumatic tubes.

Courtesy of Barker and Wheeler, Engineers, New York City.

Figure 40. Dispatch Board.

When a lot is started, the "traveler" and the stores requisition are sent to the storeroom. The "traveler" is then attached to the material and the latter is sent to the proper department. The order of work for each machine is determined by the planning and scheduling department, which lays out the work on a planning board in order to show when the operation should begin and when it should end on each order. At the completion of each operation departmental truckers move the lot to the next work center indicated by the "traveler." Workmen are assigned to machines by the foremen. As each man finishes his job, he literally "blows" his time ticket to the central dispatch board, where it is time-stamped and the ticket for a new job is stamped and sent to him by the dispatcher. The latter finds this next job in the order of work ahead of the machine. The duplicate time card goes to the worker; the original is placed in slot No. 1 and thus indicates that the work is on the machine.

Orders for parts may also originate from the balance-of-stores cards. These cards are checked daily to determine whether a supply of parts has become exhausted, or whether a shortage is likely to occur in the near future. If it is thought advisable, a production order is issued. The procedure for handling this order is identical with that for stock orders and likewise begins with the pulling of the "traveler," time cards, and requisition from the planning department file.

The handling of special orders differs from that of stock items only in the preliminary work of planning. Obviously, drawings and bills of material must be prepared for each order of this type, and this work can be done only after the order has been received.

The progress of orders is followed up by an expediter, who is given a copy of the order by the order department. He checks as to shortages of parts and the progress as required by the delivery promise. In general, he acts as the "gadfly" to keep production moving.

Questions:

1. To what extent does functionalization reduce the burden of responsibility on the superintendent and the foremen?

2. Indicate the connection between the functionalization of production planning and the availability of data concerning machine capacities and output standards.

3. How does distance of work from the planning department affect the decision as to whether dispatching should be done by foremen or by dispatchers?

4. An English company functionized the control of production in order to break up favoritism by its supervisors in distributing work to its employees. Discuss the pros and cons.

5. How are routing and the order of work affected by permanent set-ups of machines?

6. Indicate the effect on production planning of the introduction of a rush order.

CHAPTER 17

Planning and Control of Office Operations

EVEN though the principles and the methods of control apply equally well to clerical work and to factory operations, usually no clear-cut distinction in the former is made between planning and control. This important difference in the control of clerical and factory operations arises from a number of causes: since the product of the office (paper work and service) is very much simpler than most factory products, the methods of doing work are correspondingly simple. The route or path of work through the office is usually predetermined and embodied in the procedures and routines. Moreover, the operations are of relatively low cost because of the low value of office machines and equipment compared with those of the factory. And finally, some 10 per cent to 30 per cent of office operations are not measurable and are therefore extremely difficult to control.

In the office, planning in the broad sense represents research directed toward permanent improvements. It deals with the development of better routines and procedures, the improvement of methods and equipment, the design of forms and standardization of paper, the preparation of office manuals, and changes in layout. Such work is ordinarily done under the supervision of a planning committee or by an office methods department.

Since no functional planning of the type studied in connection with factory operations is used in the control of office work, day-to-day planning is done by the supervisor. Consequently, control is secured chiefly through supervision and the use of routines and procedures.

If the supervisor is to secure minimum costs and still maintain his schedule of work, the ideal arrangement is to have a uniform volume for each hour of each working day, and to have the work flow steadily to each operator. However, in practice, this ideal is rarely attained. Peak loads occur annually, seasonally, monthly, daily, and even at intervals during the day. These fluctuations may be minimized by research, by improved mechanical and operating methods, by changes in procedures, such as billing customers during the entire month instead of on the first, or by cooperation among companies, such as that between banks concerning the exchange of checks or between purchasing agents and suppliers.

Where peak loads are unavoidable the supervisor is forced to adopt one or more alternative methods. These fall into two classes: those that make the physical work itself more flexible, and those that make the working force more flexible.

If the volume of work on an operation such as stenographic dictation fluctuates during a period of time, planning and control can be made more effective by centralizing the activity. Since the decision to centralize cuts across two or more departments, it must be made by top executives.

Flexibility in the work itself. Some of the methods resulting in more flexible work are the transfer of jobs from a congested to a slack department, the "contracting out" of excess volume to other firms, and the creation of a backlog of work. An example of the last is to be found in a large soap company, where the balancing of accounts receivable is not done currently but is allowed to accumulate until the end of the month.

Flexibility of the work force. Some of the more important methods of securing flexibility of the working force itself are as follows:

1. Staggering the hours of work of the force. By this method, groups of workers are started at intervals, for example,

every two hours. No one group works more than the regular hours, yet by the time the load of work is at its peak, a maximum number of operators are on the job.

2. Development of versatile workers capable of doing any clerical job. This permits the transfer of workers from "valley," or slack, operations to "peak" operations. It requires an information transfer point to which requests for additional help and notice of excess man power are relayed.

3. Regular use of part-time employees to work only during the peak period in conjunction with a skeleton force employed regularly on the work.

4. Employment of temporary workers for peak loads, or the use of overtime for the regular force.

Centralization of office work. Centralization means the inclusion in one administrative unit of similar work that is ordinarily performed in a number of departments where it is considered a part of the work of each, such as filing for the sales, credit, purchasing, and legal departments. Centralization can be used to good advantage in such typical office service activities as typing, transcribing, calculating, filing, duplicating, stenographic activity, and mail and messenger service.

Not only does centralization make possible a better balance between work load and clerical manpower, but it permits the use of uniform practices and the development of cost-saving methods. The investment in equipment such as typewriters, calculating machines, and duplicators is usually less in a centralized department. Maintenance and machine replacement policies are simplified and strengthened.

The greatest danger incurred by centralization is the impairment of service to departments using the centralization. The supervisor must maintain a balance between internal economies and sufficient manpower to meet overlapping calls for service.

Scheduling. Periods of rush work can frequently be avoided and deadlines for reports and special clerical jobs, such as pay-roll changes, can be met by scheduling. Due dates for each report are worked out with regard for proper utilization of the staff, the processing time required, and the needs of the user of the report. In the tabulating department, for example, regularly recurring statistical analyses can be given their weekly or monthly "delivery dates," and special studies can be scheduled for specific completion dates so that work irregularity is minimized.

On repetitive and routine operations, such as computing pay roll or typing purchase orders, scheduling may take the form of individual work assignments. Through a suitable control board the supervisor establishes an order of work for each clerk that consists of a sequence of job assignments, consonant with his capacities, for a day or week.

Where volume is heavy, as in the order processing department of a mail-order company, the block system of scheduling is frequently used. A block is merely a period of time such as fifteen minutes and all blocks are of the same length. Enough work is assigned to the block, whatever the time interval, to fill it. Control is centered on the movement of blocks.

It is apparent that effective office scheduling requires the measurement of work and the use of output standards.

Routine control of clerical work. In the detailed control of a department the supervisor's problem is primarily one of utilizing labor. Although machines may be used extensively, the speed of the operator largely determines the amount of production secured from the machines. The supervisor must therefore know the capacities of his operators in assigning work to them, and must assiduously follow up their individual and group accomplishment. In doing this he will often use both daily records of individual performance and a daily report of the volume of work completed, with reasons for the retarding of any portion of it. Summaries of daily results should be made each week for the executives for whom the office supervisors work. A typical daily volume report for an order department includes the following information:

Number of orders on hand at the beginning of the day.

Orders received during the day.

Orders completed.

Orders on hand at the end of the day.

Reasons for failure to complete the number of orders for which the department has been equipped and manned.

A similar report for a central stenographic department contains the following information:

Number of lines on hand at beginning of day	240
Lines dictated	2,730
Total	2,970
Lines finished	2,880
Reason for work left over: tardy dictation	90

A less detailed method of control is one in which the department head watches only key individuals or departments and depends upon the effectiveness of the system and the watchfulness of the subordinate supervisors to keep work moving through those steps that he does not superintend. For instance, in the policy department of an insurance company, complaints were received from the field that too much time elapsed before policies were mailed out. An analysis of the situation revealed a somewhat alarming condition: only 1.8 per cent of the policies were issued the same day as they were received; 2.8 per cent by the end of the second day; 3.6 per cent by the third day; 7 per cent on the fourth; and 13.4 per cent by the end of the fifth day. Experience indicated that at least 30 per cent of the policies should have been issued the same day they were received, and 70 per cent, by the end of the second day. Control sheets were installed only at the critical points in the routine. Within nine months conditions had so improved that the percentages completed by the end of the first day and by the end of the second day were 32.1 and 71.1 respectively.

Sometimes a color system is used to spot lagging work and to indicate priority. In a mail-order company, each day of the week is given an identifying color that appears on the wrapper to which the order is attached. A variety of colored wrappers on any day indicates the relative right-of-way of each—blue-Monday before green-Tuesday—and how far each has fallen behind in the general schedule.

Control through costs. Because of the difficulty of using the planning and control devices suggested, many companies prefer to rely chiefly upon expense analysis to keep their clerical work in hand. Various plans may be used, such as budgetary control, or standard costs, depending upon the degree of control warranted. Usually the more elaborate devices are justifiable only if the volume of clerical work is large.

Perhaps the simplest method of cost control is the "work-unit" plan, in which total departmental expenses are divided by total production in units for the purpose of expressing them on a unit basis. Obviously, this method is not absolutely accurate. Its value lies in the fact that significant increases or decreases in total departmental cost can be determined easily and quickly as a guide to appropriate action. Such a device is applied only to variable and semi-variable costs, which are within the control of the office supervisor. Examples of such costs are salaries, overtime pay, telephone and telegraph, and stationery and supplies. Comparison may be made with past costs per unit or, better, with a standard unit cost. In establishing the work-unit plan, it is necessary to have an accounting system that will allocate expense items to individual departments, and to select a unit of production that varies with departmental expenses. In some cases a single over-all unit for the business as a whole may be found. Usually, however, it is advisable to employ separate units for each department; for example, "number of checks written" (cashier's department), "number of invoices written," and "pounds of mail opened and sent out" (mailing department).

The more elaborate cost analyses endeavor to secure control by making possible the scrutiny of the major items of office expense. In the expense budget of a purchasing department the six activities that incur expense are "general control," buying, research and specifications, reception, filing, and stenographic. Expenditures are divided into four categories: salaries and wages, supplies, costs of work space, and miscellaneous. The accounting system permits the accumulation of these expenses separately for each of the six groups, so that comparisons with the budget can be made for each group and for total expense in each category. In addition, actual expenses can be expressed on a unit basis (per purchase order issued), a method that enables the head of the department to determine quickly—but only approximately—the over-all tendencies in his operating costs. It also enables him to screen out the influence of changing volume in comparing experience between periods.

It is possible to develop accurate standards for the prorating of office service department costs, such as Ediphone, computing, and typing. For internal control within the service unit, standard costs can be established for each type of "product" rendered by the service units. Detailed comparisons are then made for every major class of expense.

The final test of the value of any method of expense analysis is whether it facilitates rather than hampers control, for excessive red tape merely paralyzes executive action.

Questions:

1. Discuss the pros and cons of the use of a centralized typing pool.
2. Contrast office planning and control with factory planning and control.
3. What is a satisfactory unit of measurement for:
   (a) Order writing
   (b) Filing
   (c) Comptometer operation
   (d) Typing
   (e) Filling requisitions in a storeroom
4. How would you determine the number of employees needed in a purchasing department?

Section VII

PRICING AND SALES CONTROL

CHAPTER 18

Sales Planning and Control

THE problems of planning and controlling the activities of marketing are similar to those of planning and controlling production. The several techniques involved, market research and analysis, sales forecasting, the planning and control of sales, and distributive costing are important in their own right. In addition, it is essential to understand in what respects they resemble and differ from their counterparts in the management of production.

Market research and analysis. Market research and analysis is the study of markets and marketing methods. It may be applied either to the competitive situation and prospects of an entire industry or to those of a particular company. Examples of such research are studies of population data, national income, consumption data, building contracts, price and inventory trends, and sales results.

Market analysis is used to ascertain the position of a company relative to that of each competitor, the location, wants, and buying power of the potential buyers of the company's product, and the appropriateness of its distributive system. Such analysis is important, since it contains the factual basis for an intelligent decision as to the choice of products to be made, the price at which they must be sold to secure both adequate volume and profits, the distributive outlets to provide sales volume with low selling expense, the determination of balanced sales territories, and the intensity with which these areas should be developed. In general, the thinner the distribution of buyers, the larger the territories must be, and the thicker their distribution the more it pays to sell intensively.

The benefits of market research and analysis have been well stated by Dr. Lyndon O. Brown:

1. They keep a business in touch with its markets. . . .
2. They eliminate waste in marketing methods.
3. They develop new sources of profit through the discovery of new products or markets.
4. They are insurance against unanticipated changes in the market which have the power to make a product or an industry obsolete. . . .
5. They can be used for sales promotion purposes. . . .[1]

Product market analysis. One form of market analysis, which may be termed product market analysis, has to do with customer reactions to changes in design. Customers react favorably to certain sizes, shapes and appearance; unfavorably to others. The kinship between such studies and the technical research of physicists, chemists and engineers incident to the development of the product in the laboratory is evident. The first type of research has to do with the appeal design of the product; the second with its functional design.

Quantitative market analysis. Market analysis of the quantitative type yields information as to the sales potentials of each product and of each territory. These potentials reflect the ability of a given market to absorb a given product, and are a useful basis for deciding how much advertising and selling effort to expend, and for setting sales quotas. In its results, though not in its methodology, quantitative market research resembles time-study analysis and studies of machine capacity.

Sales forecasting. Whereas market research emphasizes the *potential* markets for a given product in a given territory, sales forecasting focuses upon the results that may be *expected* in a given period. The sales forecast may be arrived at by

[1] Lyndon O. Brown, *Market Research and Analysis*, pages 5-6. New York: Ronald Press Company.

estimate, or by statistical methods. An estimate is frequently developed by combining the predictions of individual salesmen, based on their knowledge of conditions in their respective territories. Such estimates may be overly optimistic or pessimistic and are therefore usually modified by top management in the light of their broader perspective. Or, better, the company's information as to general business conditions is transmitted to the salesmen before they are asked to estimate. By the application of formal statistical methods, forecasting projects into the future the tendencies found in the data of past sales experience. To forecast effectively, comparable data for at least one business cycle are required in order that valid seasonal patterns and the cyclical trends may be determined. These, in turn, are then projected into the future with due regard to general business prospects.

The expected volume of business for the company as a whole should be broken down into sales quotas for each territory by months or quarters. In many companies a sales quota is set up for each salesman in the organization, and its attainment is made the basis for a financial bonus or for a competitive award. The sales forecast is important, too, in planning company operations and expenses.

Sales planning and control. In its broader aspects, sales planning begins with the analysis of what can be sold and at what price, the channels through which it can best be moved, and the territories in which it will be distributed. It includes the development of a program of sales promotion to assist salesmen and dealers. It also includes the preparation of catalogs and advertising copy, and the development of methods for packaging and displaying the product.

The broad planning of sales is done at headquarters. It deals with the sales and advertising programs as a whole as well as with the selection, training, and assigning to territories of the selling force. In so far as these activities relate to the design and merchandising of the product they are of mutual concern to both marketing and production executives. Merchandising may be looked upon, therefore, as an activity lying between marketing and producing, and serving to link them together.

The detailed planning of sales is done both by individual salesmen for their respective territories and prospects, and by the headquarters staff. In both cases it involves the planning functions of routing, scheduling, and dispatching.

Either the salesman himself, or someone at the branch or home office determines the most advantageous path for him to follow in covering his territory. It should be noted that sales routing deals with the sequence of calls for the salesman himself; production routing deals with the sequence of operations for a shop order.

Whether sales routing can be done better by the salesmen or by a headquarters planning staff depends upon the number of salesmen involved and the location of the requisite information. The salesmen, with an eye to their commissions, may focus their attention upon the larger customers and towns and fail to cover their territories with the desired completeness. The home office staff, however, may lack the knowledge of customer location essential to such routing.

The scheduling of the salesmen's calls may likewise be done either by the salesmen themselves or by a central staff. Sales scheduling deals with the times at which salesmen will "contact" customers, rather than with the times at which shop orders will be put through the appropriate machines. As in routing, the decision to centralize or decentralize the scheduling of salesmen depends upon the availability of the pertinent information and the caliber of the sales force. Headquarters scheduling facilitates the coordination of the salesmen's calls with the mailing of promotional literature, and provides the basis for a more detailed control of the salesmen. However attractive it may be to the management to keep distant salesmen on the job and out of the ball parks and movies, detailed sales scheduling entails difficulties not encountered in the scheduling of production. These difficulties stem from the fact that the salesman is not master of his own time when he is seeking an interview or making a call. The customer's wishes and convenience dictate the time at which the call will be made. Moreover, a salesman with sufficient ability to sell engineering and other high-quality products is likely to resent being told in detail by the home office where he is to go and when.

As in the factory and the office, the detailed control of salesmen is secured primarily through personal supervision and a system of records and reports. However, the area over which salesmen travel is usually so large that they have only infrequent personal contact with their superiors. Yet some supervision of the salesman is necessary in order to inspect his method of work, to give him corrective instruction, and to stimulate him to greater effort. Sales control is based on an analysis of the performance of the sales department: its sales results, selling costs, and the profit or, better, the contribution to fixed overhead and profit of each item, line of product, and territory.

Sales analysis is impossible without reports and records. The reports and records used in the control of sales are of two kinds: those prepared by the salesmen for transmittal to the home or branch office, and those maintained centrally. Some examples of the former are daily reports on the number of calls, total sales, expenses, orders lost and sold for each type of customer, and weekly summaries. Obviously the need for a report should be determined carefully to avoid consuming an excessive amount of the salesmen's time in clerical work.

Examples of headquarter's records and reports are those of sales by territories, towns, and salesmen; the kind and quality of goods bought by each customer; credit ratings; potential customers; mailing lists; trade discounts; and the sales by territories and lines of product.

Tests of the final success of the sales department are whether the expected volume of sales was secured at the anticipated profit, and whether selling expense remained within the limits set for it. To attain such a result requires a rigorous follow-up in sufficient detail to expose areas and points of weakness. It is necessary, therefore, to watch by major lines of product the changes in sales volume, profits, and expenses in each territory. Unprofitable lines and territories raise important problems. Should unprofitable products be carried as "loss-leaders" or should they be repriced? Should unprofitable territories be abandoned, worked more intensively, or carried at a loss in the interest of development?

To make sound decisions on these questions and similar ones calls for the use of distribution costing. In addition to the collection of expenses in the traditional accounts, they are allocated to the various selling activities in such manner as to reveal selling costs by functions, territories, and product. This will make it possible to answer such questions as:

1. What is the profit, loss, or contribution of each line of product, item, territory, customer, and salesman?
2. What is the cost of each functional activity, such as obtaining a new customer, making a call upon an old one, checking a customer's credit, the handling of a single sales order, and the billing of a customer?

Distribution costing gives information that may lead to sweeping changes in major policies and in the sales program.

The importance of coordinating sales and production has been emphasized again and again. To summarize some of the methods of correlating sales and production: the management may manufacture for stock; it may reduce prices in off seasons; it may design new products for slack periods; and it may devise organization practices that will encourage cooperation, and procedures for the swift interchange of information between the sales and production departments.

Coordination of sales, inventories, and production. The following description of the methods used by the Eastman Kodak Company to coordinate its production, inventories, and sales illustrates the technique required:

Forecasting for Production Control *

EASTMAN KODAK PLAN

The Eastman Kodak Company began its first experiments in stabilizing production over forty years ago when it began accumulating roll film stock during the slack season. The principle of stabilizing production has now been extended to practically all the manufacturing operations in the Rochester plants.

The methods of stabilization involve four major steps: (1) sales forecasting, (2) careful measurement of seasonal tendencies, (3) determination of production levels, and (4) control of stock levels.

The Sales Forecast

A reasonably accurate sales forecast is the most essential step in any program of production control. It is also one of the most difficult steps. For products which have been on the market for a number of years, it is helpful to measure the long-time trends graphically. Chart II shows such a graph of the quantity sales of product "A" from 1906 to date. The light line on the chart indicates the seasonal fluctuation of the monthly sales. The heavy black line is a moving annual average and indicates the trend more clearly because seasonal variation has been eliminated. While this trend obviously reflects the swing of the general business cycle, it also shows the long-term growth tendency in sales of the product. The dashed line is a curve fitted to measure this long-term or secular trend. While long-time trends may be calculated mathematically, a rather involved process, graphic methods using ship curves are usually quite satisfactory. This growth curve is rather typical. The data are plotted on semilogarithmic ruling to simplify the curve and to indicate the rates of change directly.

In forecasting the sales of new products where the historical background is lacking, the estimates may be the result of a combination of good guesses with studies of

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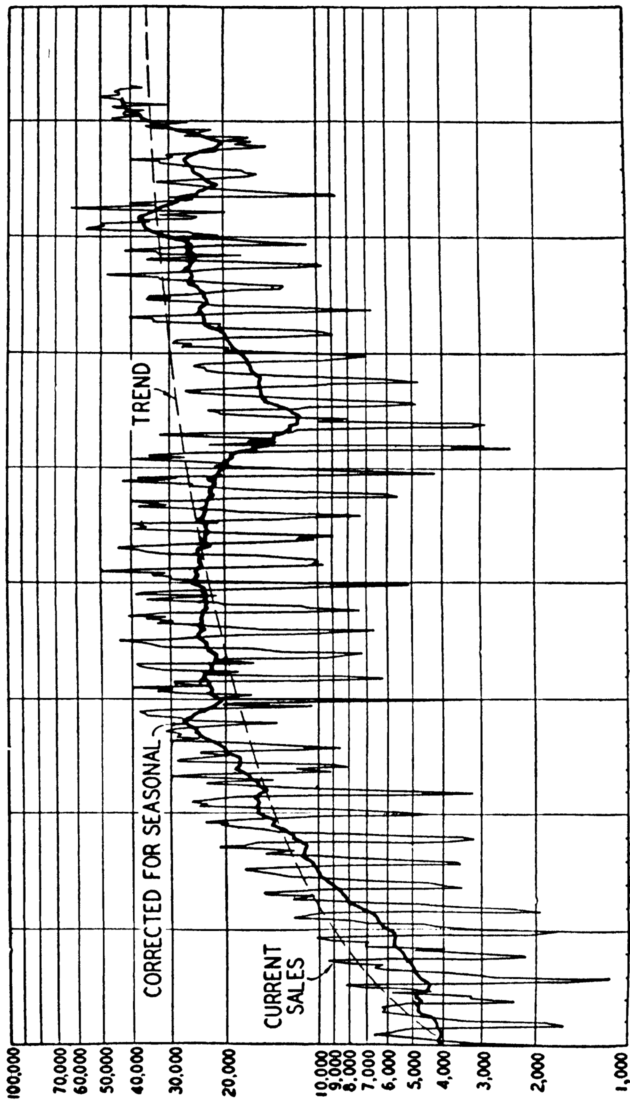

Chart II
Sales of Product "A"

the potential market, taking in consideration not only the ultimate market saturation point of the product, but the rate at which it will be approached. This may involve field studies in measuring consumer demand, and, of course, consultation with the sales division.

It is necessary that the sales forecast take into account the current state of business in general, special advertising or sales programs, new products and competition. It is quite important, therefore, that the persons responsible for the sales forecasts consult with others in the sales, advertising and product development divisions. After considering all factors which may affect the sales trend, the projection extending the corrected-for-seasonal line is entered on the chart. It is desirable that the forecast be made for at least one year. The points on the projected line are then read off month by month to give an annual estimate. The Eastman Kodak Company uses the thirteen-period calendar, so that sales and production records are kept by periods of four calendar weeks each instead of by standard months. In this case, then, the sales forecast for the year is the sum of thirteen periods.

Seasonal Adjustment

The next step is to take the projected points for the forthcoming thirteen periods and introduce the proper seasonal variations in order to arrive at the estimated sales for each period. This is done by the use of a seasonal index for the particular product. This seasonal index may be computed by any one of several standard methods for computing such indexes, depending upon which method seems best adapted to the particular case. The computation is usually based upon at least five years' sales experience, if it is available, and, where necessary and possible, adjustments are made to eliminate errors in the seasonal [sic] caused by unusual conditions in those years. (Because of the abnormal nature of business during the war years, currently it is necessary to go back to prewar sales experience to derive the proper seasonal indexes.) After this step is completed, the result is a sales forecast for the year made up of thirteen individual forecasts, one for each period.

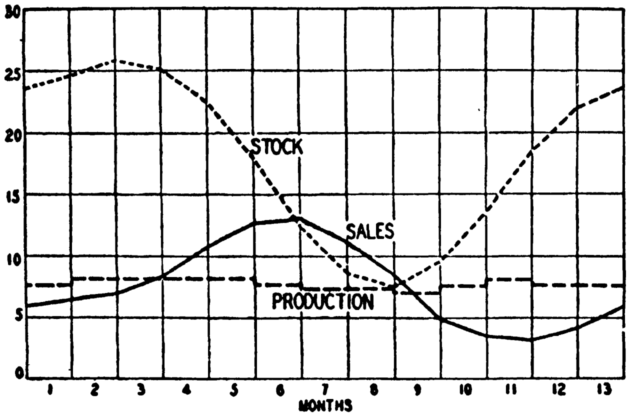

Chart III

Seasonal Variation in Sales and Stocks.

Production and Stock Control

To illustrate the principle upon which production rates are established to accumulate stocks in advance of seasonal sales, Chart III has been prepared. This is not an actual working chart, but gives in graphic form the various factors considered and summarizes the calculations involved. The heavy black line shows the normal seasonal variation for each four-week period in the sales of product "A." It is expressed, for purposes of illustration, as a percentage of each period to the total sales for the year. The interpretation of the curve is that the first period's sales are 6.5% of the total yearly sales; in the sixth period, the peak sales are 13.1% and the lowest period, the eleventh, is only 3.2% of the year's business. The sum of these percentages for all periods, then, will equal 100%.

Production Levels

Chart III also shows a curve of production. The establishment of a production curve determines the employment level and plant requirements for the year. This curve gives a straight-line production schedule which includes allowances for holidays which change the volume of production for a period even though the daily rate remains the same throughout the year. The production curve is also adjusted during the summer months to take care of the preference for summer vacations. Incidentally, this vacation peak comes at the same time as the high point of sales, which, of course, makes the problem more difficult. One of the difficulties is that such a vacation program results in the carrying of higher stocks of finished goods in the late spring than would be the case if production were constant. Practically, however, the difference is not great.

Stock Levels

Determination of the amount of finished stock to be carried at all times of the year is the fourth step. The minimum stock will come at the point when the sales rate drops below the production rate. Stock builds up until it reaches a maximum in the interval following until the selling rate exceeds production. The time of the occurrence of the minimum stock, therefore, is taken as the starting point of the calculations. The minimum stock is usually the absolute minimum that can be carried at that time of the year and yet give adequate service to customers. Stocks for each of the succeeding periods are determined by adding production and subtracting sales for each of the periods in order, beginning with the minimum. The dotted line on Chart III illustrates this accumulation of stocks and is what is called a normal stock. In this particular case it reaches a maximum of about 26% of the year's supply at the end of the second period, and is approximately a three months' supply at this period.

Stock Limits

In addition to seasonal fluctuations, there are likely to be wide and unpredictable variations in the sales from week to week and from period to period. True stabilization must involve some means of producing steadily in spite of weekly and seasonal fluctuation. Here again the stock must be made to absorb the shocks, for the normal functions of a stock of goods, either finished or in the process of manufacture, is to serve as a supply cushion to meet variations in requirements. This function of stocks is often overlooked. Stockkeepers frequently con-

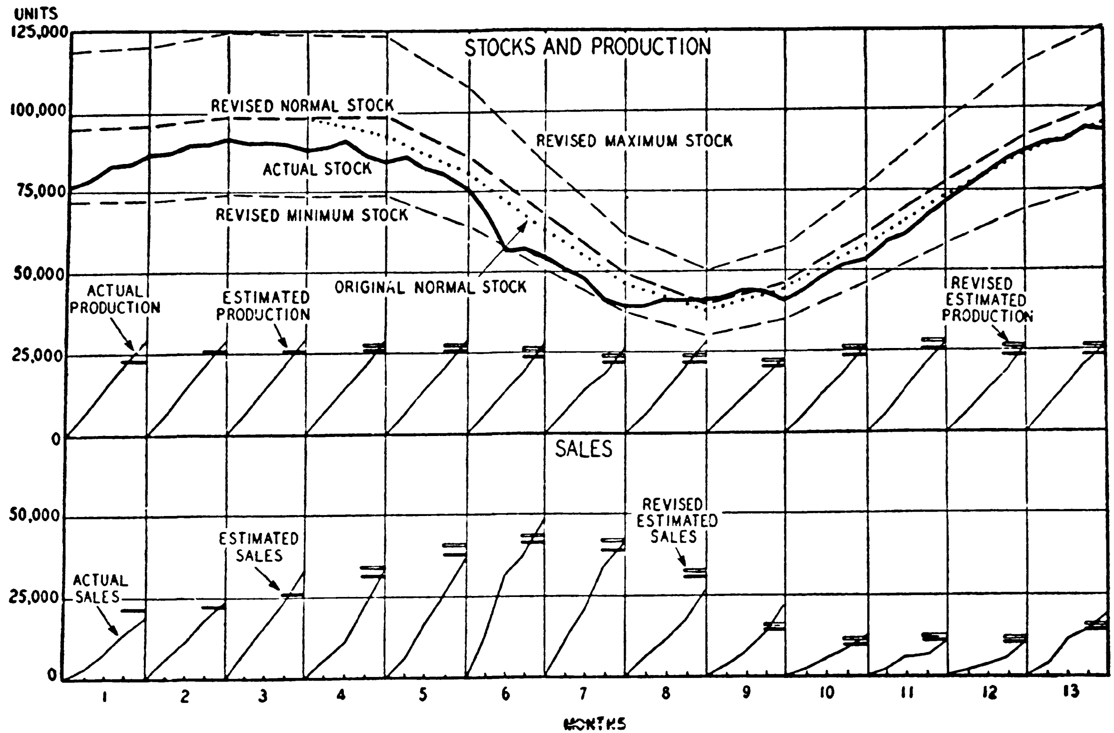

Chart IV. Stocks, Production and Sales of Product "A"

sider a definite stock figure as normal and place production orders to maintain this fixed level. The stock in such a kind of control is not serving as a cushion to absorb fluctuation, but is serving only as a place of turnover, and, in actual practice, may result in sales fluctuations being passed on to production in an exaggerated manner. Hence the reason for introducing minimum and maximum stock levels at some distances from the normal is to absorb the ordinary weekly and period sales fluctuations.

Chart IV is taken from the production control records for product "A." This chart shows, in the upper section, the original estimates of stocks. The normal stock line, expressed in units, is calculated in the same manner as in Chart III. Maximum and minimum limits are 25% above and below normal, respectively. This 25% allowance works out quite satisfactorily for most products, although it may vary according to the product or its manufacturing conditions. These maximum and minimum lines may be considered as the key to the effectiveness of the stabilization program. Plottings of scheduled production and estimated sales throughout the year are shown in the bottom two sections of the chart. As the year progressed, the actual stocks, sales and production were plotted weekly; the latter two were plotted cumulatively to compare with the period estimates. These actual production and sales figures are indicated by the light vertical lines plotted weekly for each of the periods.

Beginning with the fourth period, estimated sales were revised upward, and normal stocks were revised to conform with the new sales estimates. As can be seen from Chart IV, actual stocks stayed fairly closely within the stock limits, after revision, for the remainder of the year. The effect of the revised estimates was to schedule production at a rate so that adequate stocks were maintained and the normal stock levels were gradually approached over the remaining periods of the year.

The success of production stabilization is the result of, first, accurate sales forecasts; second, thorough study of seasonal tendencies; third, the absorption of the seasonal fluctuation by changing the normal stock level throughout the year; and fourth, the absorption of the weekly and period fluctuations through the establishment of minimum and maximum stock limits. Application of each principle must be specific for each product. Some products, such as high-grade cameras, may require six months in the process of manufacture, while other products may take only a few days to complete. Some classes of goods are in continuous production, while others are manufactured in job lots.

Particular production units may be so varied that they cannot be totaled for purposes of over-all departmental control. In such cases some common unit, such as the number of man hours, the value of labor expenditures, or the value of product may be used. In all cases it is highly desirable that a production control method be established for each principal producing department, as well as for each product. Individual products may fluctuate, but as long as the total is kept at a constant figure, stabilized production is accomplished.

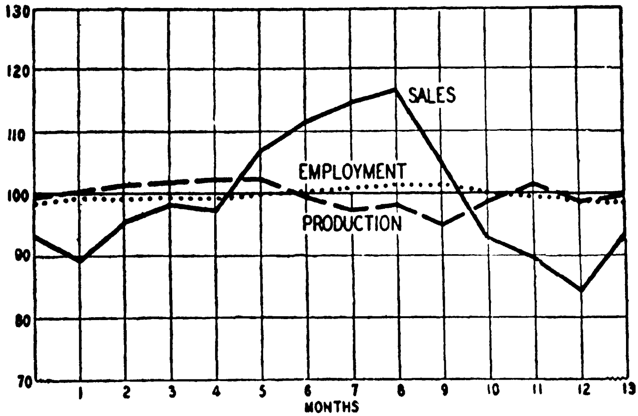

Chart V

Seasonal Indexes of Sales, Production and Employment at Kodak Park.
(Actual data based on years 1937-1940.)

Results of Plan

What have been the results of the Eastman plan? Chart V shows the seasonal variation in sales, production and employment for the entire Kodak Park Plant, with an average of about 11,500 employees in the years shown. The indexes cover the four years 1937-1940, a period unaffected by wartime allocations and rationing of product. They are adjusted only to take care of the growth element during that period. The sales index is based upon the dollar value of sales for all products manufactured at this plant. The production index is based upon man hours worked, and the employment index is based upon the number of employees on the payroll [sic] The low point in the production index was in the midsummer months when the vacation allowance was greatest, although the degree of variation was held to moderate proportions by a carefully considered program of summer vacation employment. Despite the variation in production rates which may be owing to vacations, holidays, illness, etc., the number of employees on the payroll remained quite constant with maximum seasonal fluctuations of approximately 1% above or below the average, as compared with sales variations of about 17%.

The labor turnover rate for all causes at the Kodak Park Plant for the four years was 9%, or about one fifth of the national average, while layoffs represented less than 3% of the number of employees, or one tenth of the average rate for the nation.

Relation to Other Functions

Production and selling are the two principal functions of a manufacturing concern, and practically all functions are related to these two activities. Once sales rates have been established and production rates determined, the coordination of financial budgetary control, employment, purchasing, sales and advertising activities, and other functions is a matter of organization and planning. A brief mention of some of these various relationships will indicate in general terms how an effective coordination is possible.

Cash requirements for payrolls, raw material purchases, the carrying of inventories and plant expansions are available directly from production and stock control data. Budgets for administrative, selling, advertising, accounting and distribution expenses are directly related to the sales forecast in value or quantity. Estimates of gross and net profits are derived from all these functions.

Estimates of the volume of employment and required additions to the force are directly available from the production schedules and the anticipated sales rates. The coordination of the employment division with manufacturing and selling activities permits the careful planning of personnel and industrial relations functions and can reduce the costs of labor turnover materially. Employee benefit programs can be better planned and more successfully administered when adequate data for their planning are available.

Procurement of raw materials is obviously keyed to manufacturing schedules. With scheduled receipts of goods as a corollary to scheduled consumption in manufacturing, a smoothly functioning production control permits, in many cases, the carrying of minimum raw material inventories.

Questions:

1. How would you analyze the market possibilities for a small low-priced car?
2. How would you determine the extent to which the demand for a product is affected by price changes?
3. Is there value in moving salesmen from territory to territory?
4. What factors determine the sales planning activities that can be done best at headquarters?
5. Appraise the practise of bringing oil-burner salesmen together for a "pep talk" each morning.

CHAPTER 19

Setting of Selling Prices

THE setting of selling prices is one of the most fascinating management problems. When David Harum pulled off a "hoss" deal, he could bargain face to face. Company executives, however, usually must set prices without this advantage; in fact, they may not even know who the prospective customers will be. Consequently, they often cannot accurately predict the reaction to a new price. When executives argue the pros and cons of a proposed price change, the data regarding unit costs are much more reliable than those on the all-important question of how much can be sold at a given price. Yet the executives' decision is likely to be of great importance not only to their reputations and to the financial success of the business but also to the relations between their company and its customers and competitors.

Of over-riding importance to the individual company is the effect of price changes on its volume, sales income, and profit. The income of a business is merely the physical quantity of items sold multiplied by the unit price of each item. If the volume remains the same, a decrease of 10 per cent in the average price per unit will result in a 10 per cent decline in income. What is even more significant is that a reduction of a small percentage in selling price is magnified tremendously when traced to its ultimate effect on net profit. For example, if the fixed overhead is high, a 5 per cent reduction in selling price may easily produce a 50 per cent reduction in net profit. There is also the impact of prices upon the demand for the product. This relation is difficult for managers to understand and appraise when they face decisions as to pricing. They really need to know the shape of the demand curve to answer the essential question of how much change in volume will result from a change in price. Theoretically, if the demand for a product is elastic, a price drop will increase effective demand and a price rise will decrease it. But in real life this general tendency may not hold true in the "short run." A price cut may cause buyers to withhold orders in the hope of further cuts. Even though it seems probable that sales volume will increase or decrease as a result of a given decision, the amount is extremely difficult to forecast. This is true especially if a company makes price changes infrequently and has little experience upon which to base a forecast of the effect of price changes upon volume.

Why is price setting important? The impact of pricing policy on a company's standing in its industry and on its competitive situation makes price decisions of great significance to its economic health. Not only are customer relations affected adversely if a price rise is considered unwarranted, but competitor relations may be spoiled by price reductions that start the flames of a price war. Moreover, prices may not be set without regard to legal restrictions. The federal government keeps watch over pricing arrangements that appear to be unjustly discriminatory or promotive of monopoly, and the several states have enacted both fair-trade and unfair-trade legislation.

Types of pricing situations. Price-setting situations are of tremendous variety. Consequently classification helps to delineate the vital differences. The following questions should be answered:

1. What is the degree of control over prices?
2. Are the products producers goods or consumers goods?
3. Are the goods sold standard catalog items or special order items?
4. Does the company make a single line of products or a multiple line?

Degree of control. A business man may find that he is unable to control his prices. The degree of his control varies with the nature of the product and the extent of monopoly enjoyed. He may have no control whatever over the price, the price may be regulated by governmental commission, he may have complete control over the price asked and obtained, or he may control it partially. The first is found where products, like cotton and wheat, are traded on an organized commodity exchange; the second, where prices like those of milk and utilities are regulated; the third, in those rare cases where a company enjoys a monopoly advantage without governmental supervision, as in the possession of a rare mineral or of a patented article for which there is no comparable substitute; the fourth, in the great majority of price-setting situations.

The distinction between a true monopoly, which provides the power to exploit the buying public with no opportunity for the latter to escape, and the maintenance of a strong trade position is made clear by Mr. Oswald Knauth.[1] He points out that the actual ways of business are not to be explained by concepts that are variants of monopoly, such as monopolistic competition, nor by those that are variants of free enterprise, such as imperfect competition.

> The methods of managerial enterprise and of monopoly are poles apart. Managerial enterprise must ever look after the advantages that constitute its trade position. It must offer products, terms and prices that attract customers as widely as may be. Its customers have a choice. . . . True, managerial enterprise has power but it loses that power if it abuses it.
>
> Macy's and Gimbels' in New York City are a pair of managerial enterprises unique only in the dramatic aspects of their relations. Each has a strong trade position yet neither is a monopoly. Indeed in some ways their competition resembles that associated with free enterprise. . . . Each has fields in which it is recognized to be especially

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[1] Oswald Knauth, *Managerial Enterprise*, page 170. New York: W. W. Norton and Company, Inc., 1948

strong. Moreover, in deciding upon policies, prices, and actions, each has to consider the pulling power of other similar stores. Not merely that but each must consider the advantages offered by unlike types of distribution, local, specialty, and chain stores.

Producers versus consumers goods. The demand for *producers* goods, such as steel, cement, lumber and machine tools, is relatively unresponsive to changes in price. The reasons for this are obvious. In the first place, their costs are likely, as in the case of steel destined for autos and buildings, to represent only a fraction of the total cost of the end product. "Since the cost of steel in the form sold by the steel producers is about one-tenth of the retail price of a representative low-priced automobile, it follows that a reduction of 10 per cent in the price of steel even if the saving in cost is passed on to the ultimate consumer, can effect at most only a 1 per cent reduction in the price of the delivered automobile. A price reduction of that amount . . . could bring about but a 1.5 per cent increase in the number of automobiles sold and in the amount of steel used in the automobile industry." [2]

A second factor is that capital improvements tend to be made when business is expanding, but not in periods of contraction despite the temptation of lowered prices. When the business cycle is on the rise and the expectation of profit is strong, buildings are contracted for, and machine tools bought with considerable disregard for prices, but when the cycle is declining and the outlook is discouraging, such purchases are made with caution if at all.

A third factor is the availability of capital, especially cash. A farmer whose bank deposit is growing is willing to spend cash for a new combine, corn harvester, or tractor; a farmer with slim resources tends to conserve his cash by postponing the buying of equipment.

[2] United States Steel Corporation, *Temporary National Economic Committee Papers,* Vol. I, page 267. New York: United States Steel Corporation, 1940.

A fourth influence is the economy study approach so prevalent in the buying of machine tools, hoists, and other labor-saving equipment. A machine-tool manufacturer, in a letter to Professor Schlichter, presents a cogent explanation:

> Since the experience of 1920 and 1921, in which an attempt was made by several machine tool builders to increase sales by lowering prices, it has been the general belief in our industry that this is a hopeless process, and it has not since been tried. . . . Any given proposal is ordinarily based on the length of time required to pay for the new investment. This time has to be so short to be attractive that it has to be an absurdly good proposition anyway, and 15% on the investment one way or the other doesn't seriously handicap or seriously improve the proposal.[3]

In contrast, the demand for *consumers* goods is sensitive to price changes in varying degree, depending upon the characteristics of the article and of its purchase. Mr. Oswald Knauth has drawn certain conclusions from his experience as vice-president of R. H. Macy and Company, Inc., and president of the Associated Dry Goods Corporation:

> 1. Staple articles of repetitive purchase such as cigarettes are relatively unresponsive to changes in price. They will tend to be bought regardless of increase, and a slight reduction will not stimulate demand.
>
> 2. With necessities bought intermittently, like furniture, lines priced just above the bottom sell more readily than the lowest priced ones. The cheapest goods are likely to be thought inferior.
>
> 3. The extent to which quality is hidden, as in canned goods, or susceptible of appraisal by eye or touch influences the extent to which faith in the source or in the brand name dominates consideration of price. The less easy the appraisal of quality by the consumer, the more will he be inclined to demand a known brand even at a higher price, and the less will he be tempted by price

[3] Sumner H. Schlichter. *Corporate Price Policies as a Factor in the Recent Business Recession, Proceedings of the American Academy of Political Science*, New York, January 1939, Vol. XVIII, No. 2, pages 146-147.

reductions on merchandise whose quality he does not know or feels incapable of judging.

4. If an article has gone "out of fashion" price reductions, even fairly heavy ones, fail to induce their purchase.

5. Rare articles like paintings and antiques are bought with considerable disregard of price if they possess the artistic qualities desired or are sought by collectors. The price of such items is one of the last factors entering into the purchaser's decision.

Special orders versus standard or catalog items. Typical of those who price special orders is the contractor bidding on a building or on subway work who must make his bid fit particular specifications. Woodworking establishments selling "millwork" and steel fabricating plants are in the same position; most of them do work of such a specialized nature that they are forced to submit a separate estimate on each inquiry received. The procedure is to analyze the specifications and drawings that the prospective buyer encloses with his inquiry, then to estimate the material and labor required, and finally to establish the price for submission as a bid. A concern of this type will bid on five or ten inquiries for each order received.

In contrast, a manufacturer whose products are standard can describe them in a catalog, and issue price lists that remain in effect for some time. Thus his price setting is intermittent, and his prices may be described as administered prices. If the standardization is extreme, as with cement, an individual company, if it is not the price leader for its industry, must adhere closely to the competitive price in a given locality. If the standardization is less extreme, as with ice cream and candy, comparison by prospective purchasers is not so simple. The manufacturer will often find it expedient to keep a uniform price, but to vary the quantity and the quality of ingredients sold for that price. For example, the Hershey Company and other manufacturers of chocolate bars, have long followed a policy of varying the size of the bar according to changes in costs. An ice-cream maker selling bricks and cups packed at his plant can adjust a great many elements. He may, of course, raise or lower his selling prices. Or he may change the butterfat content, making it 12 per cent, 14 per cent, 16 per cent, or 18 per cent; he may adjust the percentage of "overrun" (the percentage that the cream swells during the freezing); he may alter the quality of the flavorings; or he may even change the size of his cups.

Single product versus multiple-line products. The setting of prices for a single product, such as chewing gum, is less complex than pricing a variety of products. A paper company or a steel mill with a family of products must watch the impact of changing the price of one item upon the sales of its other items. The introduction of lower-priced models by the Packard Motor Company is but one example. To the extent that such a line taps a lower priced field or staves off new competition, it may represent a wise decision; to the extent that it competes with the older or more profitable lines of the same company, it may prove ruinous.

A hotel that takes guests solely on the American plan has merely to consider the proper differentials between its rooms "on the front" and "at the back" of the house, the rates charged by rivals, and the effect of the rates charged upon the number of guests. But once the same hotel accepts guests on the European plan in addition to the American, its price-setting problems become more difficult. It is then important to find the proper differential between the European rates on the one hand and the American rates on the other. Otherwise the management will find that it has started a cheap hotel inside its own walls and diminished its more profitable business. Moreover, such a hotel will usually add a coffee shop or some other form of European dining room. If the coffee-shop prices are too high, the guests will eat "outside," or go to some other hotel where the prices are lower. The total of the room rates under the European plan and of the coffee-shop prices must therefore not be so high as to cause a large percentage of possible guests to go elsewhere. But if the disparity between this total and the rate under the American plan (including room and meals) is too great, the guests will shift from American to European. If the hotel is designed to run primarily on the former basis, such a shift will leave many of the facilities (kitchens and so forth) unused, and the overhead will be unabsorbed.

Who sets prices? Price decisions may be made by the president, by the chief sales executive or by a committee. The larger the company the more likely are decisions on price and other sales policies to be the result of group action. The frequency with which prices are set is likewise a factor. Administered prices set at infrequent intervals frequently claim the time of a group of executives, including the president, sales manager, and comptroller. But if a company engages in special order work, it may find it necessary to prepare a large number of bids each week. In fact, as has already been pointed out, it is not unusual in such work for a company to estimate on and submit proposals for five or ten times as many jobs as are actually secured. In such companies it is customary for an estimating department working in close association with the engineering or drafting department to estimate, in detail, the material and labor costs for each job. The estimated cost is then transmitted to the sales department as a basis upon which to quote a price to the customer.

The nature of price. A price is the amount of money (or equivalent) exchanged between the buyer and seller per unit of goods and services exchanged. A market price is one made in the market as the result of the bargaining between buyers and sellers. An administered price is one set by administrative action of the seller in the light of the expected demand for the item, the anticipated cost of making and selling it, and the prices of similar items, and is held constant for some time. Administered prices, like those of new automobiles and agricultural machinery, remain rigid for considerable periods while sales volume fluctuates with the changes in demand at the established price. As distinct from administered prices that are announced publicly, the prices of goods sold to other manufacturers may be negotiated.

But prices are not always what they seem to be. Real prices differ from the nominal or published prices because of concessions of many types. Asking prices are traditionally higher than the price the seller will accept. Some of the most important concessions are discounts: trade, quantity, and cash. The first recognizes the role played by jobbers and wholesalers who must enjoy a larger discount than retailers if they are to remain in business. The proper handling of differential prices represented by trade discounts requires carefully compiled trade lists on which customers are placed in their proper class. It is often difficult to distinguish between a wholesaler and a retailer, and still more difficult to decide whether or not quantity discounts should be granted to manufacturers. Consequently, trade and quantity discounts tend to become mingled.

Quantity discounts, theoretically, are concessions to those who buy in large lots because of the incidental savings to the seller. In order that quantity discounts may have a firm foundation, the seller must draw the line between discounts that represent real savings in sales or production expenses and discounts that are merely arbitrary. For example, the cost of servicing a chain of stores is quite different from that of servicing a mail-order company, because shipments for the former must be packed separately for the individual stores. And yet both place orders that are for large quantities.

The large customer will press for price allowances with two arguments: the reduction of the manufacturer's production and distribution costs, and more effective distribution. He will argue that his business constitutes a substantial proportion of the manufacturer's volume, and thus reduces the latter's overhead cost per unit of product. Without his business, the average cost per unit would be higher. In addition to this burden absorption argument, he will contend that his business can be produced in lots that are of the most economical size.

This argument is used by a customer who approaches a flour, a cotton-spinning, or an upholstery mill with a large order. These points often enable such a customer to gain his ends.

Before accepting these low-priced orders to absorb overhead, the manufacturer should consider the following:

1. The jobbers who receive these inside discounts may resell the products at prices so low as to start price-cutting.
2. The volume won from a competitor by means of quantity discounts may lead to a price war, because the competitor is likely to retaliate.
3. To be legal, the discounts must be justified by savings.

If the argument advanced in favor of a quantity discount is the saving of distribution cost, its validity depends upon the manner in which the customer places his orders, the specified methods of packing and shipping, and the method of billing. Of course, the largest items of selling expense are the salesmen's salaries and traveling expenses. Moreover, the clerical cost of handling orders may be high. If the facts concerning these costs are known to the manufacturer, the quantity discount should not exceed the difference in the cost of handling his small and large orders.

Regarding the effect of quantity discounts in securing distribution, it must be remembered that in industries where there are rapid style changes, customers are not likely to incur the risks of quantity buying voluntarily. Moreover, if discounts are given by enterprises such as hotels, they must make careful allowance for the difficulties created if they receive repeat orders (that is, when the guests return).

However, quantity discounts generally encourage exclusive purchasing because there are times when the purchaser finds it profitable to confine his buying to a single seller rather than to divide his orders among several. Quantity discounts of the cumulative type, which are based on total purchases over a period of time, tend toward exclusive dealing more strongly than do those of the non-cumulative type, which are based on the individual transaction. If buyers need two or more items carried by a seller, quantity discounts encourage him to purchase all of them from the same source and this brings about full-line forcing.

Cash discounts are an incentive to buyers to convert accounts receivable into cash at a slight saving to the buyer. If such discounts are allowed to all buyers of the same class, they are perfectly fair.

In addition there are seasonal discounts, trade-in and freight allowances, repurchase agreements, advertising allowances, and other kinds of "free deals." "A free deal is a way of giving a buyer something more than he is supposed nominally to expect. That is, it constitutes a concession from what is regarded as a standard price." [4] Free deals are employed by manufacturers and distributors of branded merchandise who seek a method of deviating from a rigid, advertised price without destroying that nominal price. The free deals particularly associated with branded merchandise are advertising allowances. They are given especially by manufacturers who sell directly to independent retailers. Some free deals take the form of an extra amount for the standard price, as when the baker throws in an extra bun to make a baker's dozen; a soup company allows an extra case; or a cigarette company gives an extra carton.

Theoretical explanation of price behavior. For a complete understanding of the making of individual price-setting decisions, economic theory provides a useful background by explaining the general tendencies evident in price behavior. The value of a commodity tends to be fixed at the point at which the marginal cost of production and the marginal demand price coincide. The marginal demand price is the lowest price offer whose acceptance is necessary for the sale of the last unit of a given supply. But for such an explanation of price behavior to have meaning, one must understand the assumptions

[4] Leverett S. Lyon, *The Economics of Free Deals.* Washington, D. C.: The Brookings Institution, 1933.

upon which the theory is based. One assumption is that the decisions of the price setter can neither affect the prices at which his materials and labor are secured nor influence the amount demanded at any price by the market as a whole. Another is that the price setter makes a single product for which there are a number of sellers. A third assumption is that price-setting executives have a reliable knowledge of how costs vary with output. In short, a management is theoretically able to maximize profits by expanding to reach that volume at which the cost of a little added capacity is just equal to the added revenue, and by operating this plant at the rate of production at which marginal costs equal marginal receipts.[5]

But such a formal explanation, however logically it may proceed from the assumptions adopted, deals with the height of the forest in general and does not help much to understand how the height of a single tree is determined.

How are price decisions made? Whatever the kind of price situation, the central point of interest is the pricing decision. As indicated already, the price may be influenced by the market or controlled by the government, which leaves to management little discretion as to what it may charge. In such situations, management merely decides whether or not to make and sell at a given price. If, however, it can exercise discretion, it will take into account both market and cost considerations.

The market approach emphasizes the merchandiser's "feel" of the market. Based on his knowledge of customer wants, and of the goods presently available from his own and other companies, he senses that customers would accept the item in question at a given price. The top marketing executives may corral the judgment of the salesmen as to the price at which their territories would absorb the article. In this crude fash-

[5] See *Cost Behavior and Price Policy,* pages 14-20. New York: National Bureau of Economic Research, 1943 (prepared by the Committee on Price Determination for Conference on Price Research).

ion, the price setters seek to discover the nature of the demand curve. They must take into account the prices of comparable products, the durability and adaptability of the article, and the costs of maintaining or servicing it. In short, they must envisage the thinking of the prospective customer in the process of making his decision to buy or to reject at the price offered.

The cost approach to pricing decisions is no more important than the marketing approach, but is emphasized in management literature because of the wide interest in cost accounting. Business men feel that the prices charged in normal times must at least cover the cost of material, labor, and a normal share of factory overhead, selling, and administrative expenses. Variations in the risk incurred influences their thinking as to how much profit ought to be obtained to compensate for the risk, but whatever the profit objective is, the profit actually earned will depend upon the phase of the business cycle, the severity of the competition, and Lady Luck.

The cost data that are pertinent to price setting are those expected in the future; those of the past are significant only in so far as they help to predict future costs. If a standard cost system is in use, the unit costs at standard must be modified for price setting purposes to reflect the probable future prices, operating conditions, and efficiencies.

As guides to pricing, business men will most often use total unit costs, including the overhead rates necessary to absorb the fixed burden of the company at whatever volume the management has decided to call "normal." But for many situations an equally useful indicator is the variable or "out-of-pocket" cost per unit, because the excess above this figure is the contribution that the article makes to the fixed overhead and profit of the company. If the company makes one product only, this unit contribution must be obtained on a sufficient number of units to equal the fixed burden of the company before any profit will be earned. Above this break-even volume, each unit sold increases the company profit by the amount of its contribution. The concepts of unit variable cost and contribution are therefore invaluable aids to decisions as to the internal relationship of the prices composing the company's price structure, or decisions as to how low a product may be priced to dispose of an excess supply without "trading dollars."

Causes of unsound pricing. The discussion of how to set prices soundly is sharpened by an analysis of common mistakes. Some mistakes arise from unsound policies; others arise from the incorrect use of cost data.

The errors frequently made may be summarized as follows:

1. The belief, often proved to have no basis in fact, that a reduction in price will yield a sufficient increase in volume to absorb a greater amount of overhead, and thereby increase profits. The search for volume has become such a mania and is so successful in certain industries that volume emphasis has been blindly applied in many industries in which it should not be used.

2. The use of cost figures that do not allow enough for depreciation or that do not properly allocate overhead among the various lines produced.

3. Failure of a concern to select a sound basis on which to compute the profit to be included in the price. It is quite a common practice, for example, to apply a flat percentage to the cost (material, labor, and overhead). If a company analyzes its work, it will probably conclude that it is entitled to the most profit on articles that are the most difficult to produce. Does the cost of material reflect production difficulty? Often it does not, for the company merely purchases material to work into some other form, and is reimbursed by the buyer later on. In such a case, the manufacturer may be thought of as the agent of the buyer in so far as the material is concerned. The real work that he does on it is represented by the cost of direct labor, the facilitating activities, and the time of the executives. Conversion costs are therefore a reliable gauge

of the relative complexity of various products, and often form the proper basis for computing profit.

4. The inclusion in the selling price of a uniform percentage of profit on all lines of product. This practice fails to distinguish between return on sales and return on capital employed. Yet management's object is to obtain a satisfactory return on investment. This profit goal can be achieved only if account is taken of capital turnover, which is ordinarily computed by dividing the sales income by the capital invested. The desired percentage of yield on the investment may be thought of as constant, say 10 per cent, but the required percentage of profit on the sales or on the conversion cost of each line of product will vary with its turnover.

5. The sale of all articles of a given sort at a uniform price notwithstanding wide differences in size. Makers of wearing apparel often sell small sizes at a greater profit than the larger ones on the theory that the average price will be sufficient to assure a satisfactory profit. The safe rule is to make the price of each article cover its own costs so that the volume of the profitable items will not be reduced by the competition of the company's less-profitable ones.

6. Incorrect allocation of costs to by-products and joint products. Although difficult to separate the share of material, labor, and overhead expense that should be charged to each by-product or joint product, some logical basis must be developed to prevent losses on certain products from being hidden by the profits on others. "The estimated separable expenses (of each by-product) should at least be covered by the price received, and there should also be an allowance for material costs equal to that which would be received if the material were sold, or which would have to be paid if the goods were bought and devoted to similar uses." [6]

How are prices quoted? An orderly method of quoting prices is the opposite of the tactics of Eastern bazaars where

[6] See W. J. Donald, editor, *Handbook of Business Administration*, page 95. New York: McGraw-Hill, 1931.

buyer and seller, starting from a high asking price and a low offer, haggle until perchance they settle upon a price acceptable to both.

Three methods are used for quoting prices. They are as follows: from basing points; f.o.b. at the point of shipment; f.o.b at the destination. In the basing-point system all suppliers sell to a single customer at the same price, regardless of the location of the suppliers.

Basing-point systems have been used in the cement, steel and other industries where the products are standardized and so heavy that freight is a substantial part of the delivered price. A basing point is a geographical point from which the delivered prices to buyers are computed. If an industry employs a number of basing points, the arrangement is called a "multiple basing-point system." Under it, the price to any given customer is the lowest combination of base price and freight, regardless of the mill from which the customer buys.

The basing point system has been attacked by the Federal Trade Commission because the farther the customer from the source which he selects, the lower the mill net, and the closer the customer, the higher the mill net. In addition, the system has been criticised as socially wasteful because it stimulates cross-hauling, which is shipment into a territory that can be served more economically by another mill, and vice versa. Still another objection is that it facilitates price leadership and monopolistic control in that each seller knows the prices charged by other sellers.

Under f.o.b. factory pricing, prices are uniform at the point of shipment, and thus yield "mill nets" that are the same regardless of the distances between the mill and its customers, because the customers absorb the freight.

The Federal Trade Commission looks upon such prices as less conducive to the exercise of price control, and more in keeping with American anti-monopoly legislation. In Great Britain, however, the emphasis upon exporting and the concentration of domestic customers in a small area has led to a quite different climate of opinion, which has not supported such legislation.

Prices quoted f.o.b. destination are uniform delivered prices, or zone prices. These lead to mill nets that vary with the distance from mill to customer because the price quoted includes an average transportation cost. Such prices have been used for thread and other textile products, for tobacco products, candy, automobile tires, and tractors. Frequently the product has been one on which the freight has been a small part of the delivered price and the cost of its absorption small in relation to the obvious advantages of being able to advertise widely a single price that customers and distributors both know. If the freight is negligible, the zones used tend to be large; in fact, the entire United States may comprise a single zone. If freight is significant, multiple zone systems tend to be employed so that the equalization of freight over a given zone will not create too large a discrepancy between the *average* freight included in the price and the actual cost of the freight to each customer.

Legal limitations. The price setter is not a free agent. In addition to watching the reactions of his customers and competitors, he must also inform himself as to the legality of his acts. Pertinent legislation is of both federal and state origin.

The first federal law that influenced price fixing was the 1890 Sherman Antitrust Act. Though it did not refer to price fixing specifically, its provision against "restraint of trade" was construed by the courts to prohibit resale price maintenance. In 1914 the Federal Trade Commission Act gave the Commission the power, in connection with interstate and foreign commerce, to prohibit price fixing and to protect the public against price discrimination. The Commission moved against resale price contracts, and until the passage of the federal Miller-Tydings Act of 1937 it was illegal for a manufacturer to maintain the retail price of his patented, copyrighted, or trademarked goods by a system of contracts maintaining resale prices. However the Miller-Tydings amendment modified the Sherman Antitrust Act so that resale price maintenance contracts for identified goods moving in interstate commerce were legal if the goods were to be resold in a state where such contracts had been legalized for *intrastate* sale.

Of about the same vintage is the Robinson-Patman Act, which forbids, in interstate or foreign commerce, a discrimination in price between different purchasers of like grade and quantity. Discounts and allowances given to one kind of distributor were required to be offered on proportionately equal terms to all distributors. The retailer could secure the same discount as the wholesaler if he bought in like quantities and under like conditions. However, sellers might grant differentials reflecting differences in the cost of manufacture, sale, or delivery resulting from the differing methods or quantities in which commodities were sold or delivered. Price discrimination was forbidden if it tended substantially to lessen competition, create a monopoly, or to injure, destroy, or prevent competition with any person who either granted, or knowingly received, the benefit of such discrimination. In short, the Act fixed limits, based on cost savings, beyond which the preferential treatment might not go. Moreover, the burden of proof was placed upon the seller to show that a price differential was supported by a real saving in costs, after salaries, traveling, and other selling expenses had been allocated equitably as between large and small buyers. Savings in salesmen's commissions might be passed along to a buyer, but savings in brokerage (i.e., brokers' commissions) might not.

It was upon the basis of the Robinson-Patman Act that the United States Supreme Court upheld, in 1948, a ruling that was of far-reaching consequence to American industry. This ruling caused the abandonment by the cement, steel, and other industries of their basing-point systems. All of the 74 respondent companies were charged with combining to maintain a delivered-price system in order to eliminate price competition in the sale and distribution of cement, and with conduct that represented unfair competition. Upon the rendering of its decision by the Supreme Court, the cement and steel industries shifted to the familiar f.o.b. factory prices. Typical of their attitude toward the change was this statement by Ben Moreell, President of the Jones and Laughlin Steel Corporation:

> This new system of pricing will radically restrict nationwide competition. . . . We believe that an enforced continuation of this new pricing policy will promote monopolies in the areas immediately surrounding any given source of production by excluding competition from more distant sources, because of the transportation costs. In effect, a legal prohibition against meeting competition by absorbing freight will create 'tariff walls' around each producing area. It will force the closing and relocating of mills and factories. It will restrict the sales of each company to the territory surrounding its own plant. It will curtail the development of low cost production and distribution. It will deny to consumers a free choice of suppliers.

The laws that have been adopted by the states are of two kinds: fair trade laws, and so-called "unfair" trade laws.

Starting with the law enacted by California in 1931, fair trade legislation was passed by the several states to prevent price cutting. The state laws were patterned either after the California act or after the model prepared by the National Association of Retail Druggists. They were sponsored by distributors, especially those in the drug, book-publishing, and liquor industries. Manufacturers, too, were often interested in such legislation to support a resale price at which expensively advertised goods are quoted at the point of sale.

Some of these fair trade acts featured agreements that the buyer would not resell at less than the *minimum* price stipulated by the seller; others, that he would not resell at less than the *specific* price stipulated. Despite the restrictions imposed upon the resale of trademarked or identified goods, a dealer might resell below the established price when goods were damaged or when a line was being closed out.

The so-called unfair practices acts of the states have been directed against "loss leaders" and sales below cost, as well as against secret rebates where such payments or allowances tend to destroy competition.

The legal limitations that have been indicated make clear the importance of securing competent legal advice when setting selling prices, especially the prices of trademarked or highly standardized goods.

Questions:

1. Why should a manufacturer, such as Hershey, prefer to alter the size rather than the consumers' price of his product?

2. For a given industry, what factors should be considered in determining a satisfactory percentage of return on invested capital?

3. In the sale of television sets and automobiles, what are the non-price considerations involved?

4. Cite examples of "free deals."

5. From the market approach, discuss the price charged for a Crosley automobile.

6. Is it sound to charge a single price for Palm Beach suits of all sizes, or for all haircuts?

Section VIII

BUDGETARY AND COST CONTROL

CHAPTER 20

Development of Costing and Budgeting Methods

Obviously the most effective method of controlling a business activity is supervision by capable "bosses." However, the activities of even a small business are likely to be so ramified that the top manager cannot himself direct all of the departments under him. Both distance and lack of time prevent such direction. Consequently the manager must rely upon records and reports to supplement and reenforce his personal attention. In a very real sense, these data become the eyes of the administration. Through cost and other information, the chief executives are enabled both to supervise their subordinates, who are in direct charge of departments, and also to bring about the coordination of their efforts, a factor essential for effective results. The activities of the departments, particularly in a large company, could not possibly be coordinated without the use of statistical data.

The earliest recognized need for accounting was a financial one, in order to determine the amount of profits made. The need to relate selling prices to costs called for the allocation of costs to specific products. Finally came, especially during depressions, the need to control and reduce costs. This has led to improvements that are significant: standard costs for the control of material and labor; and variable budgets for the control of overhead. These were developed first to control costs of manufacturing. More recently attention has turned also to the analysis of distribution costs, an area in which further perfection of accounting techniques is needed to improve the control over selling costs.

The emphasis placed by financial accounting made its impression upon cost accounting, but in an undesirable way. First it stressed what had happened over a period of time in the past, whereas the cost data useful for either price setting or cost control must be applicable to the future. Second, by stressing actual results it drew accountants and their superiors toward what proved to be a mirage. They thought that control called for *actual* costs and strained to perfect the extent to which the figures reflected what had actually happened. As Professor Lang [1] has pointed out, the early cost accountant at first conceived his problem to be merely that of accumulating actual costs by processes or by job orders and dividing them by the number of units produced, only to discover that actual costs are hard to come by. Material costs for instance reflect the differences in the prices at which they are acquired, and "it becomes necessary to decide whether to use specific costs, first-in first-out, last-in first-out, or average costs; and if the latter, whether the average is to be simple, weighted, periodic, or moving." Even more perplexing was the attempt to determine actual overhead cost per unit. Not only did many burden items such as taxes and power defy attempts to allocate them with precision to the various product lines, but it became clear that to divide such expense by the actual number of units produced unit overhead costs that were ridiculous and meaningless. Under such a system, if depression volume fell from 100 per cent to 20 per cent of plant capacity, the actual fixed overhead per unit would increase five-fold and prove worthless for pricing decisions. Nor are actual unit overhead costs useful for control because variations in them do not reflect changes in efficiency.

To secure more reliable costs for price setting, so-called actual overhead costs were replaced by predetermined over-

[1] Theodore Lang, *Concepts of Cost, Past and Present*, page 1378. New York: National Association of Cost Accountants, July 15, 1947.

head costs based on normal capacity. This had the effect of eliminating variations in the number of units of product used as the denominator for dividing into the overhead to secure the unit costs. How much production to call "normal" was settled by administrative decision, but whether high or low the result was a stable and known quantity. The resulting unit costs were a much improved basis for setting prices but not a means of controlling the overhead expenses. (To control them called for still another development, variable budgeting, which will be discussed later.)

Nor were actual historical costs completely satisfactory for controlling the wastes of material and labor. Such historical costs played a useful role when conditions affecting the use of material and labor remained relatively unchanged; in fact, "year-ago" figures are not to be despised as a guide to decisions. But the operating conditions rarely remain unchanged. Product designs are altered; customer desires affect the mixture of products sold; the work force assimilates more or less untrained employees; and the size of the lots assigned to the workers and even the tools and equipment are altered. As a result variations in material and labor costs proved untrustworthy guides to cost reduction and control.

Consequently, standards were evolved representing what the management thought the performance *ought* to be. Yardsticks were thus created for comparison with actual amounts spent so that the resulting variances would guide the management to remedial action. These yardsticks were the logical extension to the control of material and labor wastes of the concept of predetermined costs that had previously been developed for overhead. *Necessary for adequate control of the two big variable cost items, material and labor, standard costs proved better also as guides for pricing because they reflect the future costs toward which management is striving.* In addition, they facilitated the pricing of inventories.

The coordination of the several activities of an enterprise, which is essential to the over-all planning and control of its operations, was not forthcoming from cost accounting, but it did materialize with the advent of budgeting.

Budgets are of two types: fixed and variable. The first assumes that the forecast of sales will prove to be correct and builds up fixed estimates of income, expense, and profits on this single forecast. The second is based on the assumption that the sales forecast will not be accurate and that the budgeted expense allowances should be adjusted to the actual volume after it becomes known. A variable budget provides automatic adjustment to changes in volume alone; other changes in products, prices, and costs call for revisions. The fixed budget provides a profit goal for businesses of all types; its usefulness for expense control is limited, however, to those enterprises whose sales volume and income are relatively stable and predictable. Examples are public utilities, colleges, and municipalities.

If the budget is regarded as a preview of the profit and loss statement, one of its most important functions is that of enabling management to take steps while there is still time to effect changes that otherwise it would regret having overlooked. The budget tends to give executives an opportunity both to obtain a general view of the direction in which the company is headed, and to bring their own departments into line with the general policies and program of the business.

Professor McKinsey has emphasized the point that "one of the most important by-products of the budget is that it promotes cooperation between the various executives in the organization in the solution of their mutual problems." [2] He has pointed out that in large companies the coordinated budget, as we now know it, represents a matured type of organization control—a sort of middle ground between the one extreme, where a chief executive delegates large responsibility to the executives in charge of the various company units or plants, and the other extreme of excessive centralization of

[2] J. O. McKinsey in the *American Management Association Bulletin*, 1928, Annual Convention Series, No. 65, pages 16-17.

authority. The first arrangement has often proved expensive and wasteful because losses resulted before the weaknesses of the inefficient executive became apparent. The second extreme centers nearly all the authority and control in the home office, and restricts the man in the field and hinders his development. The preferable middle ground of "decentralized responsibility but centralized control," which is characteristic of corporations like General Motors, is greatly facilitated by the development of the modern form of budget.

Prerequisites of effective budgeting. The prerequisites of effective budgeting are:

1. A sound organization in which the responsibilities of each person are defined clearly and do not overlap. This situation is essential for successful budgetary control and is needed whether or not there is a budgeting system.

2. Reliable cost accounting, first, to provide executives with comparative data concerning the past performance of their departments as a basis for making plans and estimates; and second, to provide throughout the budget period comparisons of actual results with the budget. To perform this function, it is essential that the accounting classification should correspond with the organization responsibilities that have been assigned. Otherwise, it is impossible for a chief executive to determine accurately how well a subordinate has performed his task, and the subordinate in turn either feels that the confusion is detrimental to his interests or uses it as an alibi.[3]

3. Forecasting and research needed to refine the estimates of line executives, and to furnish the top management with an objective appraisal of what is *likely* to happen and what

[3] "If the organization outline represents the units of responsibilities and duties upon which the success or failure of the enterprise depends, then obviously it represents the units in which all costs and records should be kept if the chief executive is to exercise an effective control over the situation. The units for which individuals are responsible are the sources of success or failure, and unless records are kept in terms of such sources, general administration has no means of appraising individual unit or individual executive performance." J. H. Williams, *Scientific Management in American Industry*, page 271. New York: Harper and Brothers, 1929.

should be accomplished. Forecasting is used in connection with budgeting, to estimate probable sales volume and prices as well as operating expenses. To predict orders statistically requires the determination of the seasonal index for the company's product, the trend of its sales (that is, the rate of their long-time growth or decline), and the effect of cyclical influences.

Forecasting is concerned with estimating what is *likely* to take place and research concerns what *ought* to be accomplished. If an item is financially important, careful analytical study, or research, is necessary to determine what standards *should* be used. For example, waste of material and boiler efficiency are both worthy of technical study; the consumption of rubber bands may not be.

4. Provision made in order to secure flexibility, by adjusting the estimates of expense to actual volume as soon as the volume becomes known. Only thus does the budget become a fair "measuring stick" for executive performance.

Formation and operation of the fixed budget. The process of preparing a coordinated budget starts with those responsible for results, who plan for the conduct of their several departments. The budget should be initiated by the person who is responsible for the functioning of it. These separate plans represent departmental budgets; combined, they are the master budget for the business as a whole. For a manufacturing enterprise, the principal departmental budgets are as follows:

1. The sales budget (Figure 43), for which the sales department is responsible.
2. The production budget (Figure 44), for which the production, or operating, department is responsible. This budget also includes the inventories and maintenance.
3. The financial budgets (Figures 41 and 45), for which the treasurer is responsible.

The financial budget most closely related to operating control is the cash budget. This budget is exceedingly simple. It shows, in addition to the cash balance at the beginning of the period, the flow of cash into and out of the business during the period and the balance anticipated at the end. It is especially useful to companies in which the cash position is low or in which cash expenditures fluctuate widely as in seasonal

		Cash Receipts	Cash Disbursements
January 1	Balance on hand	$400,000	
	Non-operating income	8,000	
	Collections from accounts receivable	787,500	
	Payroll		$116,150
	Material		316,800
	Taxes and rent		2,400
	Insurance		1,080
	Repairs		4,950
	Power and light		6,000
	Oxygen and acetylene		4,800
	Misc. factory expense		4,260
	Selling expense		116,094
	Administration expense		12,000
	Interest on bonds		15,110
	Interest paid		1,400
			601,044
March 31	Cash balance		$594,456

Figure 41. Cash Budget (First Quarter).

industries. It permits the treasurer to make certain that cash will be available to meet tax, pay roll, dividend, and other needs on the dates required. The management of a company's cash resources is important if cash is to be available for a great variety of needs. In addition, supplementary, or subordinate, budgets may be drawn up for purchasing, for pay roll, for research or development, for new plant, or for alterations. The relationship of these departmental budgets is shown in Figure 42. The master budget will often take the form of an estimated profit and loss statement.

Although the budget procedure should not follow a hard and fast method, such as might be suggested by the steps outlined below, the latter stress the essential elements of the problem.

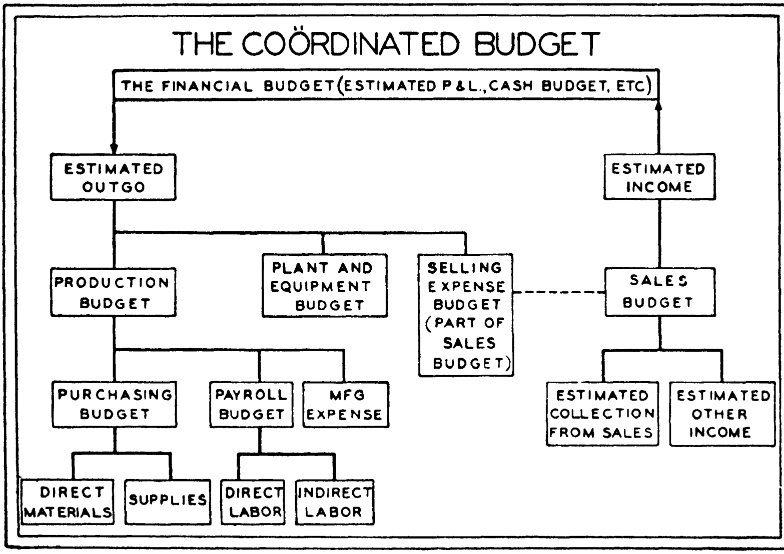

Figure 42.

Steps in preparation of fixed budget. The steps involved in the preparation of a fixed budget are as follows:

1. The informing of department heads as to the general administrative policies that have been decided upon as a guide for the business during the period covered by the budget. These policies will cover any new products that the company intends to bring out; changes in the amount of advertising; the installation of new equipment; and changes in wages and salaries. Purchasing and inventory policies that the management wishes to follow because of expected price changes and

the desired growth during the next budget period should be taken into consideration.

2. The provision of full information to the department heads concerning the past results achieved by these men during previous periods. These figures should cover the volume of sales or of production, as the case may be, the expenses in detail, and any other information that will help the department head to judge past and present tendencies. Without this basis, he cannot be expected to devise money-saving expedients or to make out an intelligent program for his department, and the value of his estimates will be greatly minimized.

3. The planning of future operations of each division of the business (that is, sales and production) and of each of their subordinate departments. For the sales division, this involves the preparation of estimates of sales in physical units, of sales income, and of selling expense. For the production division, it requires the planning of the number of units to be produced after taking into account the changes in finished stock inventory desired during the period. From this schedule of output, the production executives in a business with a standard product can estimate the material, labor, and variable expense required, a relatively simple matter. If the product is entirely unstandardized, however, it may be impossible to estimate material or even to calculate the probable output in physical units. In such a case, the labor and overhead items may have to be computed per direct-labor hour or per machine hour (see Figures 43 and 44).

4. The consolidation by the budget officer, or comptroller, of all the departmental budgets, and the preparation of the financial budgets.[4] In many instances, the financial budget may be merely a profit and loss statement drawn up for a future period; in others, it includes a cash budget and sometimes an estimated balance sheet showing the anticipated

[4] See Figure 42 (The Coordinated Budget) and Figure 45 (Estimated Profit and Loss Statement).

VOLUME	1st Quarter Budget	2d Quarter Budget	Total Budget
HOME OFFICE			
Orders Received Man Hours	9,000	12,000	21,000
Shipments.....Man Hours	8,100	8,400	16,500
Shipments.....Dollars	60,750	63,000	123,750
NEW YORK OFFICE			
Orders Received Man Hours	20,000	40,000	60,000
Shipments.....Man Hours	18,000	21,000	39,000
Shipments.....Dollars	135,000	157,500	292,500
PHILADELPHIA OFFICE			
Orders Received Man Hours	20,000	32,000	52,000
Shipments.....Man Hours	30,000	18,000	48,000
Shipments.....Dollars	225,000	135,000	360,000
OTHER OFFICES			
Orders Received Man Hours	55,000	75,000	130,000
Shipments.....Man Hours	49,500	54,000	103,500
Shipments.....Dollars	371,250	405,000	776,250
Total Orders Rec'd.........Man Hours	104,000	159,000	263,000
Total Shipments..Man Hours	105,600	101,400	207,000
Total Shipments..Dollars	792,000	760,500	1,552,500
EXPENSE			
HOME OFFICE			
Expense of the Office.......	1,500	1,500	3,000
Share of Gen'l Sales Exp....	4,410	4,410	8,820
Total..................	5,910	5,910	11,820
NEW YORK OFFICE			
Expense of the Office.......	18,000	18,000	36,000
Share of Gen'l Sales Exp....	9,930	9,930	19,860
Total..................	27,930	27,930	55,860
PHILADELPHIA OFFICE			
Expense of the Office.......	21,000	21,000	42,000
Share of Gen'l Sales Exp....	11,910	11,910	23,820
Total..................	32,910	32,910	65,820
OTHER OFFICES			
Expense of the Office.......	30,600	30,600	61,200
Share of Gen'l Sales Exp....	18,744	18,744	37,488
Total..................	49,344	49,344	98,688
Total Expense of Offices......	71,100	71,100	142,200
Total Gen'l Sales Expense....	44,994	44,994	89,988
Grand Total Sales Expense....	116,094	116,094	232,188

Figure 43. Simplified Sales Budget. For steel fabricating to customers' order.

	1st Quarter Budget	Actual	Variance	2d Quarter Budget	Total Budget
DIRECT LABOR					
Man-Hours.......	105,600			101,400	207,000
Dollars at $1.00...	105,600			101,400	207,000
Steel............	316,800			304,200	621,000
FIXED OVERHEAD					
Non-Controllable					
Taxes and Rent	2,400			2,400	4,800
Insurance........	1,080			1,080	2,160
Depreciation......	11,390			11,390	22,780
PARTLY CONTROLLABLE					
Repairs..........	4,950			4,950	9,900
Indirect Labor....	10,550			10,550	21,100
Other Expenses...	8,840			8,840	17,680
SEMI-VARIABLE					
Power and Light..	6,000			6,000	12,000
Oxygen and Acetylene......	4,800			4,800	9,600
Other Expenses...	4,260			4,260	8,520
Total Shop Overhead.	54,270			54,270	108,540
Grand Total........	476,670			459,870	936,540

Figure 44. Simplified Manufacturing Budget. For steel fabricating plant, manufacturing to customers' order.

position of the company at the end of the budget period. This consolidation process should harmonize the budgets from the department heads with those prepared by the staff men in the accounting or the statistical department. *If they are widely divergent, the president himself should undertake to harmonize them in a manner satisfactory to all.*

Questions:

1. Why is a fixed budget applicable to a college, fraternity, or municipality?

	1st Quarter Budget		2nd Quarter Budget		Total Budget	
Gross Sales (Shipments)	$792,000		$760,500		$1,552,500	
Less Returns and Allowances	4,500		4,500		9,000	
Net Sales		$787,500		$756,000		$1,543,500
Less Cost of Sales		476,670		459,870		936,540
Gross Gain (or Loss)		310,830		296,130		606,960
Less Selling Expense	116,094		116,094		232,188	
Less Administration Expense	12,000	128,094	12,000	128,094	24,000	256,188
Operating Profit (or Loss)		182,736		168,036		350,772
Less Other Deductions:						
Interest on Bonds	15,110		15,110		30,220	
Other Interest Paid	1,400		1,400		2,800	
Discount Allowed	1,600		1,600		3,200	
Total	18,110		18,110		36,220	
Plus Other Income	8,000	10,110	8,000	10,110	16,000	20,220
Net Profit		172,626		157,926		330,552

Figure 45. Budgeted Profit and Loss Statement.

2. Appraise the use of a fixed purchasing budget for department store buyers.

3. How may budget "padding" be minimized?

4. Criticize a blanket order to reduce all departmental budgets for indirect expense by 10 per cent.

5. To what extent are historical costs useful?

6. Outline step by step how you would develop a schedule of purchases from the sales forecast.

CHAPTER 21

The Variable Budget

VARIABLE budgets, sometimes called flexible budgets, provide budget allowances adjusted automatically to changes in volume. They may take the form of alternative budgets, one for each 5 per cent or 10 per cent change in volume; or they may be represented by the formulae for the several items of expense, fixed, semi-variable, and variable.

Automatic adjustment to volume gives the variable budget an advantage over the fixed budget as a control device, because the fixed budget is a yardstick only if the volume realized is identical with the volume upon which the budget has been based. Except in the most stable industries, such a development is unlikely in the extreme; if it happens at all, it must be attributed to luck. Consequently when operating executives are asked to explain variances from a fixed budget they are almost certain to possess a ready-made alibi, "The volume was different." With a variable budget, however, such an excuse is not valid because the budget allowance has already been adjusted to the volume actually attained.

Variable budgets cover material and labor costs, as well as overhead expense, for the control of which it is particularly suited. The overhead expenses involved may belong to manufacturing overhead, to sales overhead, to administrative expense, or to the general fixed charges not allocated to any of the other three. The volume to which these should be related is not necessarily the same. Manufacturing burden should obviously be related to the number of units fabricated. If a part of the product is made for stock, the sales overhead may be related more appropriately to the units sold than to the units made. The same reasoning may apply to administrative expense and to fixed charges.

Fluctuations in volume may be measured readily if the product consists of a single line that may be counted in pieces. It becomes more difficult as the product mix becomes more complex and variable. A mixture of castings ranging from the simplest to the most complex cannot be accurately counted in pieces as can the product of a foundry making cylinder blocks alone. If units of product made or sold are inapplicable, then management must resort to an alternative measure. One is pounds. Another is man-hours of direct labor, which is useful only if labor efficiency remains relatively constant. Another is machine-hours of work completed but with the same qualification. Still another, dollar sales, is the least desirable of all because of fluctuations in selling prices and in the product mix.

A prerequisite to the control of overhead costs is the separation of the variable portion, which is a function of volume, from the fixed portion, which is a function of time. Some costs, resulting from the investment of capital in buildings, tools and equipment, remain fixed for long periods. Of such are costs like property taxes and bond interest, which involve cash expenditures, and depreciation, which does not.

In contrast to these are short-run fixed costs, such as executive salaries and part of the indirect labor pay roll. For instance, the plant protection force can be reduced or expanded by decision of management without waiting for the expiration of a given period of time, but it is likely to remain unaffected by moderate changes in the rate of production. These short-run fixed costs are partly controllable in total amount (at least, they are more controllable than long-run fixed costs once the latter have been incurred), but on a unit basis they vary with changes in volume. Unit costs that include such fixed costs are therefore quite meaningless to a management bent on preventing waste.

In contrast, the variable portion of the costs is more controllable. Once these have been segregated, they can be controlled by watching variations from the standard of the actual costs per unit. Since these costs should remain constant per unit, failure to hold them constant and at the established standards is a signal to management to investigate the cause of the variance.

The variable budgeting procedure calls for the determination, in advance of the budget period, of certain cost constants, and after the period has ended and the actual volume is known, the calculation of what the expenditure for each item should have been. Before the period, the management should know the constant cost of each item for a given time as well as the constant cost per unit of volume. After the period, the budget allowance for each item can be calculated by adding to the fixed cost the product of the variable cost per unit and the units of volume. If the fixed expense per month is $10,000 and the constant cost per unit $10, the budget allowance for 2,000 units would be $30,000; for 3,000 units, $40,000.

In preparing a variable budget, no difficulty will be encountered with direct material and direct labor because these costs are constant per unit of volume and the standards per unit are usually available. The difficulty arises with those costs that are fixed regardless of volume, or which are semi-fixed or semi-variable in that they are influenced by changes in volume though they do not vary directly with it. An example of "fixed" costs is property taxes; an example of semi-fixed or semi-variable is indirect pay roll.

Whether it is desired to express the variable budget as a series of alternative budgets (see Figure 46) or as a mathematical formula for each expense item, the data can be developed best by studying the past impact of volume on each item of overhead expense. What is needed is cost information of recent vintage for a series of volumes sufficiently different to permit a valid line to be drawn through them reflecting for that item the relationship of costs to volume. To determine the slope, two volumes are required as an absolute minimum; to have confidence that the line represents the cost-volume relation, the more figures the better, provided they represent the present operating condition and the prevalent level of prices.

To show how the cost constants for time and volume (i.e. the fixed cost per period and the variable cost per unit) are determined, one may resort, as has Mr. Fred V. Gardner,[1] to data for automobile operation. Suppose monthly costs for six months had been as follows after arranging them according to miles run.

	Mileage	*Monthly Cost*
1	500	$40
2	700	44
3	900	48
4	1100	52
5	1300	56
6	1500	60

If these particular monthly costs are plotted on a chart of which the base line is miles run, the points will fall on a straight line; in practice such costs will not fall precisely on a line, and the line of "best fit" must be determined either by crude observation (which may be good enough) or by the more refined statistical "least squares" method. Once this line has been found, typical costs for any mileage may be ascertained from it. The variable cost per unit can then be determined by dividing the difference in cost between a high and a low mileage by the difference in miles. In the illustration cited, the total cost of 1500 miles per month is $60; of 500 miles per month, $40. The additional cost of 1,000 miles is $20 or $.02 per mile. The variable cost at the high volume is $.02 × 1500 or $30 and at the low volume,

[1] Fred V. Gardner, "The Meaning of Breakeven Points." *Production Series 177,* American Management Association, 1948, pages 11-12.

Drill Press Department					Doakes, Foreman
Direct Hours	2600	2800	3000	3200	3400
Per Cent Capacity	65	70	75	80	85
Foremen	$80	$80	$80	$100	$100
Clerical	72	72	72	72	90
Total Supervisory and Clerical	152	152	152	172	190
Oilers and Sweepers	39	42	45	48	51
Internal Transportation	21	21	21	27	27
Other Indirect Labor	132	141	150	159	168
Total Indirect Labor	192	204	216	234	246
Grinding and Polishing Wheels	15	18	18	21	21
Paints, Lubricants and Waste	18	18	18	21	21
Stationery and Office Supplies	3	3	3	6	6
Miscellaneous Supplies	15	15	15	15	18
Total Operating Supplies	51	54	54	63	66
Machinery	117	126	135	144	153
Motors	24	24	27	27	30
Semi-durable Tools and Instruments	351	378	405	432	459
Miscellaneous Equipment	12	12	12	12	12
Total Maintenance	504	540	579	615	654
Employees Welfare	6	9	9	9	9
Miscellaneous Expense	12	12	12	12	15
Total Sundries	18	21	21	21	24
Grand Total	917	971	1022	1105	1180

Figure 46. Weekly Indirect Expense Budgets.

$.02 × 500 or $10. Subtracting these amounts from the respective total costs gives a constant cost of $30 per month. The variable budgeting formula for this car (arrived at from satisfactory past experience) is $30 per month + $.02 times the number of miles run in a month.

If, during a budget period of a month, the actual miles run were 1150, the adjusted budget would be $53. If the actual cost were $52, the variance of $1 would not stir us to action; if \$60, however, the variance of \$7 would cause us to examine both the fixed costs to find out if an increase in garage rent or insurance were the cause and the variable costs to find out if the carburetor adjustment or car speed were at fault.

In this simple case, the fixed cost may be built up in the traditional way by totaling the various identifiable amounts, \$20 for depreciation, \$5 for insurance, and \$5 for garage rent. In practice the fixed cost often cannot be determined accurately by this traditional method because certain items, such as pay roll, are neither pure fixed nor pure variable, but a mixture. (See the analysis later in this chapter of the data in Table 8.) These semi-variable items lend themselves to analysis by the variable budgeting approach if it is assumed that within the usual range of volume the relation of total cost to volume is a straight line.

This simple example, which has been based on the operation of a car, may be duplicated for an enterprise as a whole. If the breakeven chart data in Chart I are employed, the variable cost per unit is the difference in total cost at the high and low volumes divided by the difference in units, or \$250,000 ÷ 50,000 units = \$5. The fixed cost, calculated by subtracting the variable cost for either volume from the total cost for that volume, equals \$350,000. The contribution to fixed overhead and profit is the unit selling price of \$10, less the variable cost per unit, or \$5, and the breakeven volume is the fixed cost divided by the contribution per unit, or 70,000 units.

Application of variable budgeting. The manner in which budget allowances are adjusted to actual volume is shown by the case that follows. The basic budget data for a manufacturer of shoes are shown for two rates of operation. From these data the expense formula for each item is developed when the budget is first established. The budget allowances are computed after the end of the month when the actual production is known. Then these adjusted budget allowances are compared with the actual costs in order to reveal variances.

The monthly budget data are:

TABLE 8

	Low volume 30,000 prs.	*High volume 60,000 prs.*
Material	$ 30,000	$ 60,000
Labor	40,000	70,000
Factory Overhead	10,000	15,000
Administrative Expense	10,000	10,000
Selling Expense	15,000	25,000
Sales Income	105,000	210,000

The *formula* for each item of expense may be developed by ascertaining the variable cost per unit, then the total variable cost for either the low or high volume, and finally subtracting the total variable from the corresponding total cost to obtain the total fixed cost. For example, the variable direct labor cost equals the difference in cost divided by the difference in volumes, or $30,000 ÷ 30,000 pairs, or $1.00 per pair. The total variable direct labor cost for the low volume is therefore $30,000, and the total fixed cost is $40,000—$30,000, or $10,000. In the above example, a quick computation reveals that there is no fixed cost for material and no variable cost for administrative expense.

For each of the expense items, the fixed cost per month and the variable cost per unit are as follows:

TABLE 9

	Fixed cost per month	*Variable cost per unit*
Material	0	$1.00
Labor	$10,000	1.00
Factory Overhead	5,000	0.1668
Administrative Expense	10,000	0.00
Selling Expense	5,000	0.333

The actual expenses for a month in which 42,000 pairs of shoes were made were: material, $42,867; labor, $53,260; factory overhead, $11,860; administrative expense, $9,940; selling expense, $20,400.

The adjusted budget allowances for a volume of 42,000 pairs and the variances appear below:

TABLE 10

	Adjusted budget	*Actual data*	*Variances Losses*	*Variances Gains*
Material	$ 42,000	$ 42,867	$ 867	
Labor	52.000	53,260	1,260	
Factory Overhead	12,000	11,860		$140
Administrative Expense	10.000	9,940		60
Selling Expense	19.000	20,400	1,400	
TOTALS	$135,000	$138,327	$3,527	$200

Questions:

1. Compute the budgeted breakeven point of this shoe manufacturer.
2. What is the premise upon which variable budgeting is based?
3. How does variable budgeting diminish the alibis offered by department heads?
4. Are budget adjustments and budget revisions synonomous?
5. Are the following statements true or false?
   (a) Variable expenses are constant per unit.
   (b) Fixed expenses are variable per unit.

CHAPTER 22

Standard Costs

In the past, management was supplied with the actual cost of production. Of necessity, this information was historical in that it related to what had already been finished. Under earlier cost systems, the figures collected and distributed were often so detailed that the clerical cost was excessive, and the presentation of the information to the executives was so delayed that remedial action could not be taken promptly.

The manager of a company is interested in costs from the standpoint of control. This control can be obtained best if certain standards have been set up against which actual accomplishments can be measured; for reliable comparisons, so-called standard costs have been developed. These are predeterminations of what costs either *ought* to be or are *likely* to be in the future. Such standards may represent what management research, such as time study, reveals they ought to be, or they may represent forecasts of what is expected to happen to wage rates and material prices. Comparison with them is more useful than that with the costs of some previous period. To compare the present manufacturing cost of an article with its cost when last produced is of little significance to the factory manager in determining the efficiency of his plant. The manager has no assurance that the last time the article was manufactured, material, labor, and overhead were utilized as economically as they should have been. In short, what is needed to bring about real manufacturing control is the establishment of measuring sticks with which the manager can compare actual accomplishment with the accomplishment that he has a right to expect.

As in the case of all management standards, these costs are subject to revision when there is a change in the fundamental conditions under which they were established. If, for example, a machine is installed to perform work previously done by hand, the labor standards for the operation must necessarily be revised. Likewise revisions are required when material prices rise or fall, or when wage rates are adjusted.

What are standard costs? [1] By setting up measuring sticks with which efficiency can be judged, standard costs are valuable in controlling operations because they focus attention on variations from the established standards and permit the analyzing of these variations to ascertain the reasons for them as a basis for corrective action. In addition, standard costs simplify the cost-accounting system and thus reduce its cost of operation, increase the speed with which cost information is supplied, and furnish the sales department with information regarding volume and price for the establishing of sound sales policies.

Standard costs may be defined as predetermined costs for each operation that are set up and collected on the basis of production centers or departments. The concept of standard varies and may represent long-run "normal" standards, changed infrequently, or standards changed frequently enough to be considered "current." In either case standard costs represent the proper costs of doing business, regardless of whether actual costs are above or below them. These disparities or variances from standard, if they are losses, measure the wastes that management seeks to correct in order to achieve the desired efficiency. These wastes are not only identified but traced to the person responsible.

[1] Standard costs are to be distinguished from uniform or standard cost-accounting systems used in many industries. In such cases the term is used to designate uniform accounting methods.

Uses of standard costs. Whether to use actual or standard costs for the pricing of inventory is a question regarding which opinions differ. Some accountants maintain that the costs used should include all the costs of making the goods left in inventory, and that the variances should be added to the standard costs in determining its value. Others hold that standard costs provide the proper basis for pricing inventories, because they exclude the costs of wastes that are considered avoidable. This difference in point of view diminishes in importance when the standards used in the standard cost system are relatively close to being attainable. In any case the problem is solely one for those concerned with financial accounting; it has nothing to do with the causes of variances that interest operating executives.

It must not be assumed, however, that the use of standard cost data precludes the use of actual costs. Both are needed to reveal the variances that reflect inefficiency, and the latter are necessary to portray the overall financial results to the investing public. Under job cost systems, so commonly associated with historical costs, the amounts spent for material and labor on a particular job are accumulated and, on some basis of allocation such as man-hours, a share of overhead is apportioned to the job. When the job is shipped, these amounts are totaled to obtain its actual cost. Under process costs, the amounts are likewise accumulated for the process up to a given point. Under neither job nor process costing are the data related directly to managerial responsibility. The labor cost of a job may be higher or lower than the last time the job was manufactured, but the differences are not traceable to the individuals who have caused them.

Control of costs requires not only that variances be brought to light but that they should be so reported as to reveal how well each part of the organization is discharging its responsibility. It has been said that an accounting system is in tune with the organization only if individual names can be substituted for account numbers.

One of the peculiar virtues of standard costs as a mechanism of control is that the method focuses attention upon the causes of loss. Such an analysis brings to light the weak spots in the organization, and makes it possible for the manager to concentrate his attention upon removing the causes of inefficiencies. Information is brought to light while there is still time for remedial action. For example, it is possible to obtain the weekly (or daily) efficiency of each operator by merely keeping a record of the actual time he spends in the plant, and comparing with it the total standard time of jobs finished by him. A recapitulation of these data provides the corresponding information for each department and for the plant as a whole.

Moreover, many operating executives can control the quantities of labor or material used but not the prices at which they are acquired. The prices paid for raw material may be influenced by the purchasing department but certainly not by the factory superintendent and his subordinates. Therefore, since the use of the data should dictate the design of the cost system, the practice has developed of splitting each cost variance into two parts: that attributable to inefficiency in use, and that attributable to price. Of these two categories, the former is the more helpful in achieving control.

To split such variances requires that the standards be expressed in physical units as well as in money. Standard quantities are necessary to determine usage ratios that measure waste. Inefficiency in the consumption of steel bars in a forge shop or of raw cotton in a cotton mill is reflected best by comparing the actual consumption in pounds with the standard quantities allowed for the production turned out. Similarly, labor inefficiency is revealed best in percentage of efficiency, which is computed by dividing standard hours allowed by the actual hours paid for. In both cases the variances expressed in pounds, hours, or percentages of efficiency are preferable to those expressed in money.

But price variances have their place. To measure the ability of the purchasing department to acquire materials and supplies at the price that management had predetermined requires a comparison of actual dollars spent with standard dollars allowed. Similarly, price variances are needed to detect the cost of assigning jobs to employees who have higher rates than those contemplated when the standard labor costs were set. Only thus can the waste be detected of sending a "man on a boy's errand," as when a first-class man is assigned to work for which second or third-class men are adequate.

Setting cost standards. The setting of cost standards should be approached primarily from the engineering rather than from the accounting point of view. The procedure involves setting the lowest practical cost standards consistent with the operating conditions of the business, and with the quality and service required. The standard cost of material is determined by a careful analysis of the physical quantity required to manufacture the article, plus a reasonable allowance for waste. The total is known as the standard usage factor. This should not be determined by guesswork or by accepting past performance, which may represent wasteful usage, but rather by detailed analysis and study. This standard quantity is then priced at a standard purchase price set as close as possible to the anticipated price. Once determined, this basic price should be used without change in calculating all unit costs for products using that material. For example, in manufacturing shirts of a certain class the standard usage of material per dozen shirts is 15 yards, and the standard cost per yard of material is 60 cents. If, in manufacturing a lot of 50 dozen of these shirts, 760 yards of material were actually used and its actual cost per yard was 66 instead of 60 cents, then the variance in material cost would be as follows:

	Actual	*Standard*	*Loss*
Quantity	760 yards	750 yards	10 yards
Material Cost	$501.60	$450.00	$ 51.60

This excess of actual over standard cost may be explained as follows:

10 yards over standard at 60 cents	$ 6.00
760 yards at 6 cents over standard price	45.60
	$51.60

The use of the additional ten yards may have resulted from the carelessness of the cutter. The variation in price may have been caused by the use of more expensive material than was necessary, or by an increase in the purchase price.

Similarly, the standard labor hours should be determined by time study. The standard labor hours are multiplied by the standard rate per hour for that operation to secure the standard labor cost of the product. If piece rates are used, these naturally become the standard labor costs. Suppose that, on a given operation in the manufacture of shirts, the standard time per dozen, arrived at by time study, is 0.5 hours, and that the hourly labor rate is $1.00. If the actual time taken to make 50 dozen items was twenty hours, and a worker whose rate was $1.10 per hour had been assigned to the job, the variance in labor cost would be as follows:

	Actual	*Standard*	*Gain*
Hours	20	25	5
Labor Cost	$22.00	$25.00	$3.00

The labor saving is explained as follows:

5 hours saved over standard at $1.00 per hour	$5.00
20 hours taken at 10 cents per hour over standard rate	2.00
Net Gain	$3.00

In this case there was a gain in efficiency, and a loss in rate, with a resulting net gain of $3.00.

In setting standard overhead rates, it is necessary both to budget expense and to determine the capacity on which the burden rates are to be based. A standard overhead rate is a ratio of budgeted expense to "normal" capacity. For example, if the overhead expense budget of a department (or of a machine center) were $50,000, and the normal capacity, 50,000 man-hours, the overhead rate per man-hour would be $1.00. By "normal capacity" is meant the theoretical maximum capacity adjusted to the sales demand over a period of years. The standard overhead rate may then be arrived at by a method best fitted to the conditions of the given plant. After the expense budget and the capacity have been determined, the standard overhead rate is expressed as a rate per man-hour, per machine-hour, or per unit produced, or as a percentage of direct labor. If the rate of factory operation is below "normal," the actual factory overhead will include idleness expense, representing that portion of fixed and semifixed expense that has not been absorbed by the actual production.

Applicability to all company divisions. Although standard costs are peculiarly effective in controlling material and labor costs, their use should not be limited to the factory, since they may also be applied with advantage to the selling and administrative divisions.

Standard costs can also be used to analyze both the profitability of the various lines of product being manufactured. and the sales efficiency of the various sales districts and salesmen. Their use in the control of sales expense was described by G. Charter Harrison, an early advocate of standard costs, in the following statement:

> The complete cost system carries the engineer's idea of predetermination to its logical conclusion; not only are costs predetermined but sales expenses and profits are also forecasted, providing a definite objective for each division of the business. The cost accountant prepares a monthly statement showing the actual profits in comparison with the forecast and an analysis of the causes of any variation from the forecast, showing how much of the variation was due to loss of sales; how much to cuts in sales prices; how much to sales expenses; and how much to manufacturing costs, etc. Supporting this are detailed statements which analyze the profit losses in complete detail, showing by districts and salesmen the effect of failure to realize stand-

ards and providing similar detailed information regarding factory inefficiencies.[2]

Questions:

1. Indicate the relation of standard costing to:
   (a) The development of output standards.
   (b) The development of operating standards.
2. Distinguish between standard costs and variable budgeting.
3. Which variances would you require the following individuals to explain—
   (a) The purchasing agent.
   (b) The sales manager.
   (c) The factory superintendent.
   (d) The employment manager.

[2] G. Charter Harrison, "Costs as an Aid to Management." *Annals of American Academy of Political and Social Science*, May, 1925, page 63.

Section IX

WAGE AND SALARY ADMINISTRATION

CHAPTER 23

Types of Compensation

A problem that is central to both industrial and personnel management is the determination of employee compensation. It affects the amount of pay roll the company must carry, as well as its unit labor costs. It is an important factor in obtaining and maintaining an effective work force. Not only does the amount of pay influence a company's ability to get and keep competent employees, including executives, but the manner of payment influences their attitudes toward their work and therefore their effectiveness.

As employee compensation takes a great variety of forms, clarification of them is essential to an understanding of wage setting. One fundamental distinction is that between basic and incentive compensation. Basic compensation is pay based upon time worked, such as day work pay and salaries. Incentive compensation is based upon output or some other measure of performance, as is the case with piece work.

Basic compensation. The basic compensation earned by an employee is the product of the time worked and his base rate. For instance, a man whose base rate is $1.50 per hour and who works 40 hours in a given pay-roll period will earn base pay of $60.00. This illustrates the distinction between base rates and base pay. The base rate may belong either to a position or to the employee who holds it. In the first case it is a price for a unit of time placed on a position in accordance with its relative importance and the general level of rates paid by the company.

The setting of the base rate for each position calls for four techniques:

1. Job analysis.
2. Job evaluation.
3. Surveys of wage rates and salaries prevailing in the labor market.
4. The construction of wage and salary schedules for the company.

The wage and salary schedules are the concrete expression of the company's basic compensation policy. They guide the operating executives in the never-ending task of setting the hourly rates and salaries of individual employees.

If the position rate is a single rate such as $2.00, the base rates of all employees in that classification are the same; if it is a range, an employee's base rate may be at the minimum or at the maximum of the range or at some rate between. The rate actually assigned to the employee depends on management's judgment. In judging the value of an employee's work, the management will take into account the amount of his output, its quality, and his versatility and ability to work with a minimum of direction and errors.

Incentive compensation. Incentive compensation is pay that is contingent on performance. It is pay linked to results accomplished rather than to time worked. Performance may be measured in output, as in the case of piece work; in standard man-hours of work accomplished, as under the standard-hour plan; in percentage of efficiency, as in the Emerson and Wennerlund plans; in work units as under the Bedeaux plan; in percentage of work that is good or bad, as with quality incentives; in dollar sales, as under sales commission plans; in savings of budgeted costs as used for supervisory bonuses; and in net profits as used for executive bonuses.

Compensation as related to organization structure. The problems of setting base rates and incentives vary at different levels in the organization structure. The organization structure may be likened to a pyramid in which three levels are distinguishable (Figure 47).

At the bottom are the manual and clerical positions ordinarily paid on an hourly, daily, or weekly basis. To each of these positions must be assigned a basic wage rate, preferably after careful job analysis and job evaluation. These positions, if the work lends itself to standardization and time study, can usually be placed "on incentive" to facilitate the control of labor costs and the increasing of employee "take home" pay.

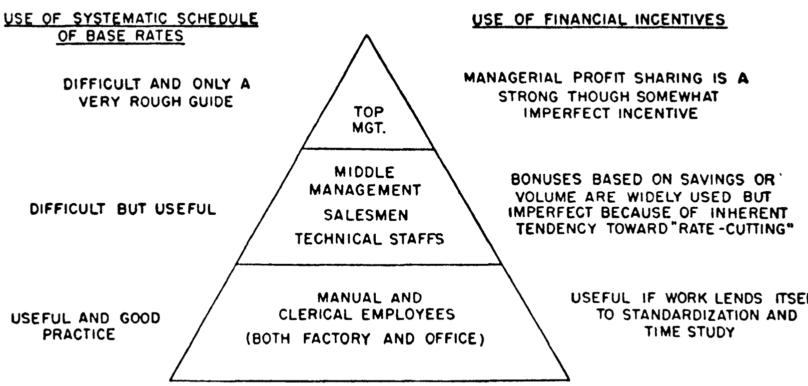

Figure 47. Organizational Levels Influencing Method of Compensation.

The second organizational level that should be considered with respect to basic and incentive compensation comprises junior executives and, in the case of many manufacturing enterprises, their selling forces. Here the problem of setting base salaries is similar in kind to that at the bottom level but it is more difficult. The positions are harder to evaluate and the salaries prevailing in other companies are more difficult to determine because of the lack of comparability. Yet it is quite feasible and worthwhile for a company to establish a salary schedule for positions in this middle level of the organization pyramid.

Incentive arrangements for these positions, however, although they are used frequently because the stimulation of salesmen and key supervisory executives is desired so greatly, may encounter a serious obstacle. They are often based, in the case of foremen on savings against budget allowances, and in the case of salesmen, on attaining sales quotas. Naturally, these budgets and quotas require adjustment as conditions change, but any tightening of them may appear to be an effort to force bonus recipients to work harder for the same pay. In short, such adjustments smack of "rate-cutting," any suspicion of which tends to undermine the effectiveness of the incentive arrangement.

For top executives, incentive arrangements based on profits are widely used. Even though profits are an imperfect measure of managerial performance, executive bonuses are a stimulus to increased effort and initiative.

It is in the setting of their base salaries that it is most difficult to employ the procedures discussed in this section. The higher the position in the organization the more the incumbent influences its content. Consequently it is difficult to describe the position apart from the executive who fills it; nor is it easy to determine the prevailing salaries for such positions. As a result, both a systematic job evaluation and the surveying of salaries are difficult, though not impossible, to apply to top managerial posts.

Supplementary pay. The amount in the regular pay envelope or pay check is called, in the language of the shop, "take-home" pay. In addition to base and incentive pay, it reflects a number of other payments. Examples of such supplementary compensation are overtime pay; premium pay for working at undesirable hours; pay for time not worked, such as pay for vacations and unworked holidays; attendance bonuses; and profit-sharing bonuses. Since the most interesting questions of policy are associated with the last two of these, they alone will be discussed.

Attendance bonuses. Attendance bonuses are intended to reward promptness and regularity of attendance. They have been used by many companies because absence and tardiness are an annoying source of loss. Their use serves to complicate the compensation program unnecessarily. The problem can be solved by proper supervisory attention without the aid of a financial incentive. Equally to be condemned are penalties that are disproportionate to the time lost. Docking and other negative incentives, though temporarily effective, are to be avoided because they undermine employee morale.

Profit sharing. In as much as profits are a goal common to both owners and managers, it is natural that attempts should be made to use them as a basis of payment. Profit sharing is extra compensation that bears a recognizable relation to company profits, and is paid under a continuing policy announced to the participants in advance. Its application to executives has incentive values that profit sharing for wage earners does not, and therefore these two applications are discussed separately.

Managerial profit sharing is confined to those executives whose jobs permit them to have an appreciable and recognizable effect on profits. The goal of owners is to use the form and amount of executive compensation that will yield the best management that the company can afford. The case for managerial profit sharing is that it is both good business for the owners and equitable for the managers in that the managers become, in effect, partners interested in maximizing profits. Contingent pay gives executives part of the profit that their skill and effort have helped to create.

In general, the record of executive profit sharing has been good, although it varies with economic expansion and recession. Their use was accelerated by the advent of high corporate taxes because extra compensation, being deductible from taxable net income, was considered to be largely offset by the taxes saved. On the other hand, the increase of individual income taxes has lessened the attractiveness of fluctuating bonuses to their recipients. One result has been an increased emphasis upon profit-sharing trusts. Payments into such funds are deductible for tax purposes and the recipients delay their tax burden until they begin to receive payments from the funds, beginning, say, at retirement. Naturally, the tax rates on pensions will be lower than they would have been on bonuses pyramided upon base salaries. Since high taxes have lessened the opportunity to accumulate a competence during one's working life, executives turn with affectionate regard toward an arrangement that helps them provide for old age.

Profit sharing applied to executives, appears to be an incentive, though a somewhat imperfect one, because profits are not an accurate reflection of managerial performance; but applied to wage earners, profit sharing does not appear to induce greater output, quality, or waste reduction. Profits are not a valid measure of employee performance, the schemes are not sufficiently simple, and the payments come after such a long delay that the incentive "pull" is weakened. Profit sharing's principal justification is the creation of trusteed funds for employee protection. Such reserves permit a company that makes substantial profits, even occasionally, to provide flexibility for itself and security for its workers. Such an arrangement is a welcome if partial antidote to the growing inflexibility of our economy and helps a company to remain competitive by providing the financial help needed when eliminations from the pay roll are necessary. Companies with fluctuating profits may, through this device, find it possible to build up employee protection that they could not risk through annuity plans calling for fixed annual premiums. Moreover, companies that enjoy profits in most years and have a well-rounded program of industrial relations may wish to consider profit sharing as a capstone, and a developer of employee morale.

This attitude of cynical optimism toward the ancient device of rank-and-file profit sharing, and that of temperate enthusiasm for managerial profit sharing, assumes that the company in question has no plan in effect and is completely free to choose. If a company has had a plan in effect long enough for a tradition to have been established, then its freedom of decision is reduced, and it may think twice about abandoning a scheme that it would prefer not to have started at all.

The mortality record of rank-and-file profit sharing plans, based on a period of a century and a quarter and a sample of over 1,000 plans, shows that about 60 per cent of the plans have become inactive.

The recent trend has been to adopt plans of the trusteed, deferred-distribution type. The Conference Board found that of 27 plans initiated in recent years, all but two are of this type. Management appears to have had little return from the payment of bonuses in cash. Instead of being saved for use in sickness, lay off, or retirement, the bonuses were frequently spent even in advance of their receipt. Nor could they be justified as incentives to improve performance.

General conclusions.

1. An essential attribute of sound wage administration is the maintenance of balance among its parts. Basic compensation should have proper internal alignment and satisfactory relation to the wage levels of the labor market and among competing firms. Basic compensation should be in balance with supplementary compensation, and what is in the pay envelope should be in balance with pensions and other collateral benefits that are not.

2. The consideration of a given form of compensation is affected by whether a company has previously had such a plan in force or not. It is frequently difficult to abandon a program that has become a tradition even though its departure might seem a blessing.

3. Profit sharing for executives is a useful incentive, but it should be used in conjunction with base salaries that approximate the market level for similar companies.

4. Profit sharing for wage earners should not be looked upon as a financial incentive. If used, it should take the form of a trusteed deferred-payment plan rather than one providing for cash bonuses that can be spent immediately. Profit sharing for the rank and file is not applicable, unless a company is

profitable, and it should not be a substitute for other portions of a well-rounded personnel program.[1]

Questions:

1. If an employee is hired to give a "fair day's work for a fair day's pay," why pay him extra compensation?

2. Contrast the incentive value of rank-and-file profit sharing with managerial profit sharing.

3. What are the alternatives to the use of attendance bonuses to reduce tardiness and absenteeism?

[1] For a more detailed discussion of profit sharing, see C. C. Balderston, *Profit Sharing for Wage Earners*. New York: Industrial Relations Counselors, Inc., 1937.

CHAPTER 24

The Setting of Basic Wage Rates and Salaries[1]

THE two essentials for setting satisfactory base rates are, first, aligning the job rates internally; and second, relating them externally to wage rates prevailing in the market. The first means that the rate or rate range of each job must reflect the difficulty and responsibility attached to it relative to other jobs on the pay roll. The second means establishing a satisfactory relation between the general level of company rates and those prevailing in the labor market from which its employees are drawn.

A sound internal alignment of rates is the product of job analysis and evaluation. Even though systematic attention to this problem is a development of the last few decades, it must not be thought that the problem of appraising job difficulty is a new one. In mature industries and labor markets, the established skill differentials have been hammered out by haggling over rates in countless wage discussions.

Such occupational differentials play an important part in maintaining a balanced supply of workers and in stimulating men to acquire the training needed for skilled jobs. They also are important psychologically. Because these differentials are considered by workers to reflect their status in the company, they cannot be changed radically without injuring employee morale.

[1] With the permission of Industrial Relations Counselors, Inc. This chapter is adapted from a study by C. C. Balderston, *Wage Setting Based on Job Analysis and Evaluation*. New York: Industrial Relations Counselors, Inc., 1940.

The balance between money differentials and job importance should extend throughout the entire range of job difficulty from janitor to president. It is not sufficient to establish a proper alignment of rates between the least skilled job on the pay roll and the most skilled nonsupervisory one, such as toolmaking. Failure to maintain the alignment on up through the supervisory positions, for example, adds fuel to the fire of discontent among foremen. To the foremen's general feeling that neither their jobs nor their status are clearly defined is joined resentment of the fact that sometimes subordinates "take home" more than they do.

If hiring rates and pay raises are not determined by a definite policy, the company's personnel relations may be weakened and a serious loss of morale may result. Managements that fail to solve this problem systematically miss a chance to demonstrate their fairness to their employees. Further, if rate differentials for the highly skilled jobs are inadequate, employees lack the incentive to receive training for, or even to accept, positions that require a relatively greater degree of skill.

Finally, the worker's tendency to compare his rate of pay, not only with that for similar work in his own place of employment but also for similar work in other establishments, is likely to reveal glaring disparities and inconsistencies. The frequent lack of company policy as to the general relationship that the company's wage rates should bear to the average rates of the labor market from which the employees come is borne out by numerous examples. For example, in a company whose working force comprised thirty-five different occupations, the rates of pay of twenty-eight of them averaged 6 cents per hour above the market rate for comparable work, three of the occupations were compensated at the market level, and the remainder received rates averaging 5 cents less than the market level. Another concern, whose employees were distributed among fifteen occupations, paid six of them an average of 10 cents above the market rate for comparable work and the rest

9 cents less than the market rate. In a third industrial plant having thirty-one occupations, nearly half of them were paid an average of more than 15 cents above the market rate and the rest 8 cents below it. These companies failed to keep the rates for their several occupations in proper alignment or in any consistent relationship with rates prevailing outside.

Purpose and function of job analysis, evaluation, and pricing. Job analysis, evaluation, and pricing aim to correct rate inconsistencies by making possible the systematic setting of hourly rates and salaries. Their primary purpose is to establish a basis for setting wage and salary schedules that will guide a company in keeping its employee rates in mutual alignment and in satisfactory relationship with those paid in other companies obtaining labor from the same source. The emphasis is on the work performed rather than on the individual to whom the work is assigned. The procedures may be utilized to establish rates for employees paid on an hourly basis and also for the salaried groups, such as clerical and supervisory employees, but they may become inapplicable when the work performed cannot readily be analyzed apart from the individuals who do it, as is frequently the case with high executive posts.

The proper use of each of the three procedures gives management the information to answer the following questions:

Job analysis: What is the nature of each job? What duties are performed? What precision is required?

Job evaluation: How do the jobs compare as to importance, difficulty, and scope of responsibility?

Wage surveys: How does the general scale of wage rates paid by the company compare with that prevailing in competing companies and in the labor market from which the employees are drawn? Is the general scale of the company higher or lower than the prevailing one, and are the differentials for skill as large as in other companies?

In addition to its direct objectives, job analysis may provide management with certain important by-products: hiring specifications, clarification of the duties and responsibilities of every job, and clearly defined promotional channels.

Since such factors as the skill and degree of responsibility involved in a particular job do not lend themselves to precise measurement, it is clear that they cannot be appraised with exactness. Consequently, job evaluation should never be considered or defended as a precise, infallible method of measurement. All of these procedures merely facilitate the setting of base rates in a manner sufficiently systematic to make for sound employee relations.

Job, or position, analysis is used for two purposes: first to secure all pertinent information about job content, i.e., the duties, responsibilities, organizational relationships and working conditions; and second, to set forth this information in accurate job descriptions.

Job evaluation is used to determine the relative importance, responsibility, difficulty and hazard of each position on the pay roll. The result is a list or "ladder diagram" (see Figure 50) showing the internal alignment of positions in non-monetary terms (i.e., either grades or points).

Market wage surveys are used to ascertain the rates for comparable occupations in the labor market from which the employees are drawn or in the industry in which the company competes. The result is a chart (see Figure 51) that portrays the prevailing rates considered pertinent to the *pricing* of the company's own occupations and positions.

The end result of these three procedures, job analysis, job evaluation, and market surveys, is to provide the research basis for the design and adoption of a wage or salary schedule to guide the setting of the base rate or salary for each employee.

Job analysis. The primary purpose of a job description is to provide a definition of each pay roll title, a uniform nomenclature for use throughout the organization, and a record of the job as constituted at the time of the analysis. A job description facilitates the appraisal of the difficulty of the particular job in relation to other jobs and is essential for comparing an individual company's wage rates with those of other firms. A complete description shows the qualifications that are desired for filling a particular job satisfactorily and thus may serve as a job specification for use in hiring new employees, or in arranging for promotion and transfer. Such a combination of a description and specification is presented in Figure 48.

JOB DESCRIPTION AND SPECIFICATION

Department *Tool* Occupation *Toolmaker*

Section ______ Class *First*

Code No. *1081*

NATURE OF WORK

Set up and operate all toolmaking machinery and use all hand and machine tools with no supervision. Make from *intricate* drawings, punches and dies, jigs, fixtures, gauges or forming tools, working to an accuracy of .0002″ with a minimum amount of supervision. Develop blanks for parts that require forming and bending. Repair any tools of this grade.

GENERAL REQUIREMENTS FOR OCCUPATION

TRAINING—Regular apprenticeship or Toolmaker—Second Class

EDUCATION—2 to 4 years high school

EXPERIENCE—9 years

ENTRANCE AGE—27 years

BREAKING-IN TIME—1 year

SEX—Male

RATE—

Figure 48. Job Description and Specification Form.

The best descriptions present a job's distinguishing characteristics rather than a lengthy and detailed delineation of duties. The objective should be a statement of duties sufficiently complete to aid in determining the real importance of the job without unnecessary detail. Moreover, the presentation should place proper emphasis upon those phases of the job that are of most significance.

In making descriptions of *hourly-paid jobs,* it has proved to be more practical for a staff member of the organization to secure the information needed than to have the employees fill out questionnaires. If used at all, questionnaires should be confined to clerical and other salaried positions, but even then their usefulness is limited. After the descriptions have been prepared, it is essential that their accuracy be checked by those who are directly in charge of the positions in question. Subsequently the descriptions should be referred for approval to higher executives, who should first be made to understand the importance of the descriptions to the whole program. When representatives of the employees participate in the evaluation, their approval of the job description should be secured first to avoid misunderstanding when the evaluation and its results are under discussion.

If the descriptions are prepared by a staff member, it is advisable to limit the initial consideration of each position or occupation to the job description proper and to leave the question of job specifications to be settled by a group rather than one individual. Decisions on such matters as the desired amount of training, education, and experience, the minimum age, the average "breaking-in" time, and the sex better adapted to the performance of the work are reached most satisfactorily on the basis of group judgment.

In preparing the job description, attention may well be paid to organization procedure. Naturally, no contact should be made with employees without "going through" their immediate superiors. No job description should be settled upon finally until all interested executives have had a chance to check its contents. Further, it must be borne in mind that changes in pay-roll title tend to modify the general organization pattern of the company, and if the traditional names of some positions need to be changed for the sake of clarity or uniformity, it is wise to make as few changes as possible.

In those companies in which the pay-roll titles represent occupations rather than specific jobs, it may prove advantageous to subdivide the occupational groups into various classes, such as "Toolmaker—first class," "Toolmaker—second class," and so forth. These classes should not be so numerous that their boundary lines are indistinct, nor so broad that they fail to separate work that is of differing importance. For example, to adopt one broad occupational title of "Lathe hand" may be unfair to those who are doing the most difficult turning. The ultimate refinement in this respect is to draft a separate description for each position on the pay roll, but such a procedure will, of course, increase the cost of the analysis.

Because of the problems involved, most companies use individual questionnaires to obtain from the *salaried* employees descriptions of the work they perform. These questionnaires are an important accessory to the processes of interviewing and observation in connection with salaried positions. But job analysts must be wary about depending solely on this source of information. The questionnaire, filled out by the employee after a proper explanation of its purpose, is only a starting point from which the analyst may secure sufficient understanding of each position to interview the incumbent and his supervisor intelligently.

The difficulty of describing the scope and duties of salaried jobs frequently tempts the analyst to depart from the standard terminology that is employed for hourly-paid jobs. It is essential always to use a terse, direct style, starting each sentence with a verb, adhering to the present tense throughout and omitting all words that do not impart necessary information. Of paramount importance is emphasis on those activities and duties that are most significant. It must be borne in mind that the description should give a correct portrayal of the identity, purpose, content, and requirements of each position, and is not meant to serve as a manual of detailed procedure.

Clerical positions present a problem for the analyst, especially in small companies, because they may combine duties of a wide range of difficulty. Illustrative cases are the telephone operator who serves as receptionist and in her spare time does simple clerical work, and the stenographer who devotes part time to supervising other stenographers. If the company involved were large enough, this work would be subdivided, assigned to different individuals, and compensated according to the skill required. When such a multiplicity of duties is combined in one position, it is advisable to prepare a separate description for each of the component jobs, because together they do not fit into any one occupational category. Since the combination of duties may vary from day to day, the descriptions must make clear the typical percentage of time devoted to each group of duties.

A still more difficult problem posed by such jobs has to do with their evaluation, since they mix work that, in the departments subject to greater subdivision of labor, is paid for at widely differing rates. This situation raises a fundamental question. Should the rate of a combination job be set on the theory that its incumbent must be able to do the most difficult of the various functions and should be paid accordingly? Such a solution, though perhaps necessary, creates a rate that would be excessive with respect to the simpler and easier tasks included in the combination. The problem is accentuated when the work is partly of the type ordinarily done by men at the prevailing market rate for male clerical workers and partly of the type usually done by women at the prevailing rate for female employees. The management may consider it best to change the job, if conditions permit, in order to narrow the range of ability required.

Job evaluation. The appraisal of an occupation or job involves the determination of its relative difficulty and importance, regardless of its place in the functional or departmental structure of the organization. Whether the results may be expressed as a series of grades into which jobs have been grouped or as a rating of difficulty in points, the purpose is to reflect the relative difficulty and importance of each job or occupation as a basis for the construction of a rate schedule.

If properly done, the appraisal will result in rates or rate ranges that are in mutually satisfactory alignment.

Simple grading or ranking may serve the purpose of companies that wish to construct a wage schedule in a systematic manner without becoming involved in an elaborate procedure. Although the final result of ranking, used alone, may not be as satisfactory in the long run as that obtainable by the more complex procedure described at a later point, it is better to establish rate schedules by this method than to evade the problem entirely. Simple overall grading or ranking may be done by asking foremen and other line executives, inspectors, time-study men, and the like, to arrange the jobs and occupations in a given department in sequence from the most to the least important.

If the company makes a practice of discussing wage setting with union officers or other employee representatives, it is likely to discover that simple grading does not help to answer the questions frequently asked as to why one job is considered more difficult than another. Simple grading does not even provide a permanent record of the job characteristics that the appraisers take into account in reaching their decisions.

A record of the way in which the appraisal was made is provided by rating but not by grading. Although some opinion holds that it is futile and inaccurate to express the rating results in points, this method has advantages for a company whose workers cover many varied occupations. The development of a rating scale (see Figure 49) requires three steps. The first is to select the factors or compensable characteristics, such as responsibility and working conditions. These should not be too numerous, but they should be sufficiently comprehensive to cover all the significant elements that contribute to the importance of a job.

The second step has to do with the choice of degrees for each factor and the assignment of point values to them. If the degrees are defined by phrases, it is important that the latter be definite and clear cut, and that vague words to indicate

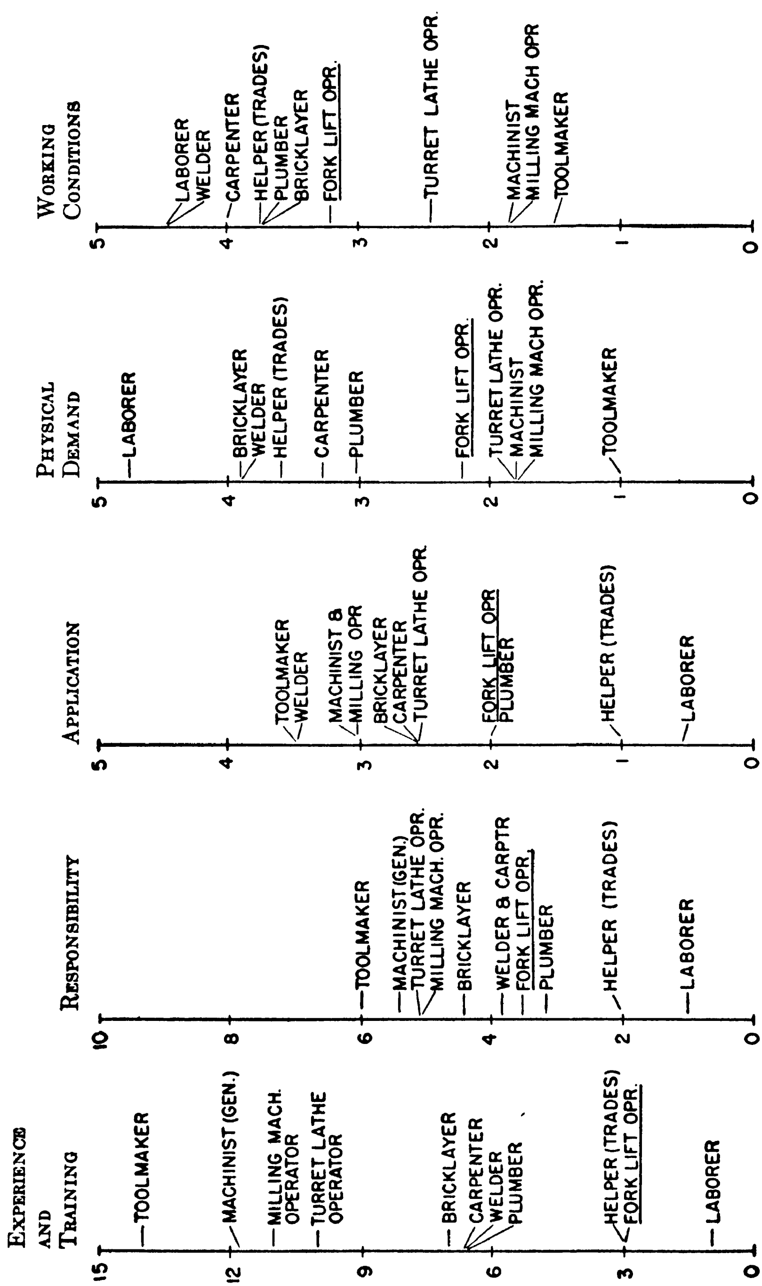

Figure 49. Rating Guide.

differences, such as, small, medium, large, should be avoided. For example, in the case of such a factor as "previous experience required," the degrees may be: six months, one year, two years, and so forth; whereas, for "contact with people," the degrees may be: none, within the same section, within the same division, with the customer, and so forth.

The third step involves the weighting of the factors selected. If desired, the more important factors may be given several times the weight of the least significant one. For example, if "responsibility" is felt to be twice as significant as "working conditions," its point values may be multiplied by some selected weight. Or the several factors may be left unweighted, which has the effect of assigning uniform weights to them.

At the risk of omitting some factors that ought to be considered in evaluating certain positions, a limited number of five to eight specific factors permits a relatively large number of raters to be used in the appraisal. Obviously, the opinion of five or ten informed and impartial individuals is likely to be better than the judgment of one, and the use of a large number of raters has the further advantage of facilitating the participation of persons in key positions in the organization. Such participation, whether in connection with the rating itself or the checking of the results, is essential to insure the acceptance of the rating.

It should be pointed out, however, that the use of specific factors and of definite point values may cause some important considerations, such as hazard, to be ignored. Moreover, a rating sheet composed of such specific factors will not usually be applicable throughout the entire organization, so that separate rating sheets will have to be prepared for the factory jobs, supervisory posts, and clerical and engineering occupations or positions.

Only the factors common to all or nearly all the jobs and occupations to be rated should be included on the rating sheet. It would be preferable to use the factors related to the nature of the work without any reference to the qualifications of persons needed to perform it. But in practice it is necessary to adopt the somewhat indirect approach of using such factors as "minimum education required," and "previous experience required." Unless these factors are taken into account together with the compensable characteristics that are related directly to the work, it will be impossible to secure an adequate basis for appraisal. The use of certain human qualities as factors, such as, honesty and dependability, is futile because they do not help to differentiate the relative importance of jobs. Moreover, it is a mistake to include factors that have to do with establishing the general wage level, such as, the scarcity of qualified applicants and the existing rates of pay; these should not be considered in the process of rating but in the later step of creating the rate schedule.

Finally, the question of how the degrees of each factor are to be expressed and the values to be assigned to each must be determined. This question may be approached in three different ways.

The first method, known as factor comparison, assumes that the rates of certain key jobs, which are common to the company and to outside firms, are in satisfactory alignment. A rating scale is then devised which, when applied to these key jobs, will yield ratings of relative difficulty that bear the same relationship to one another as the existing wage rates of the same jobs. In this method the degrees of each factor are expressed in terms of actual jobs to permit the use of job-to-job comparison. Such a rating scale may then be applied to all the other jobs to bring them into alignment with those upon which the scale was originally based.

The second method, like the first, expresses the degrees in terms of jobs rather than definitions, but ignores existing rates of pay. The point rating scale is developed on an abstract basis. The point values are selected arbitrarily according to the judgment of those responsible for the study.

The third method likewise ignores existing rates of pay, but the degrees of each factor are expressed in phrases instead of jobs. These phrases and/or their corresponding point values are so selected as to bring out significant differences in skill and difficulty among the jobs to be appraised. It is essential that each factor and its gradations be expressed clearly enough to be interpreted uniformly by all raters.

Regardless of the method adopted for developing and applying the rating scale, the results of the ratings should be submitted for review to as many qualified persons as practicable. Several devices may be used to facilitate such review before any rates of pay are determined. Perhaps the most convenient one is a diagram that resembles a series of ladders placed side by side. Each ladder represents a functional division of the business, such as, parts fabrication, assembly, service activities, engineering positions, and clerical positions. The rungs on these ladders represent the grades of difficulty that have been assigned. Such a tabulation of jobs by grade and by function enables management and employee representatives to secure a bird's-eye view of the result of the entire appraisal and to bring their judgment and experience to bear in deciding whether the result "looks right." (See Figure 50.)

The factors selected as the basis of differentiating the relative difficulty of salaried jobs must be somewhat different from those used for hourly-rated jobs. For example, in a large bank the requirement of a certain amount of formal education may not serve to differentiate the demands of one job from another. The need here is for a measure of the employee's ability to learn and to apply knowledge, rather than for a specific amount of education alone. Further, such factors as hazard, physical fatigue, and obnoxious working conditions, which must be given consideration in appraising most factory jobs, are not likely to apply to the work of salaried employees.

Market surveys. The results of the appraisal must ultimately be converted from grades or points into money. This conversion requires two steps: the determination of the rates prevailing in the labor market from which employees are secured; and the decision as to how the general slope of the company's rates is to be related to the market slope.

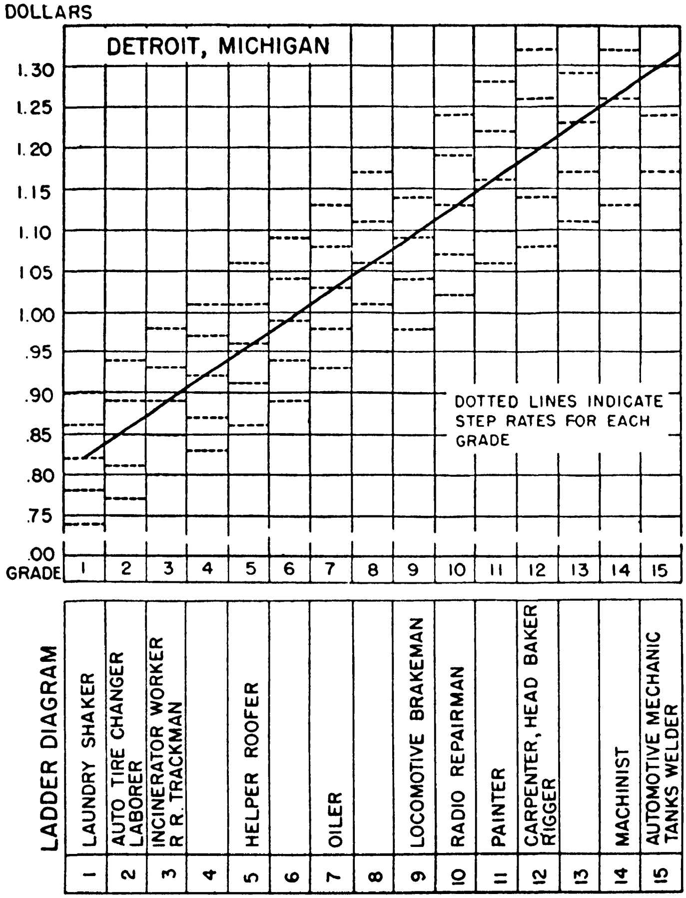

Figure 50. Ladder Diagram and Slope of Market Rates. Adapted from Rating Guide developed by Wage Administration Section, Headquarters, Army Service Forces, Manual M 202, 29 May 1944, p. 33.

Determination of the rates paid in the community or by other firms in the same industry calls for a wage survey, which is sometimes conducted by manufacturers' associations and sometimes by individual companies. In either case, the prerequisite is a set of definitions for the occupations that are common to the companies from which data are solicited. Although it is usual practice to use questionnaires for such surveys, it is preferable to have a qualified person interview the executives of the cooperating firms in order to make sure that the work for which rates are obtained conform to the definitions. While the occupational descriptions may be comparable, it is usually impossible to secure reliable data as to the productive efficiency of the workers whose rates are obtained. Output standards in the various plants are not likely to represent uniform difficulty of achievement, even if set by time study, and it is not possible to determine whether the quality standards are strictly comparable. Even if the definitions indicate the standards to be met, variations in equipment and material used will diminish the degree of comparability.

Once the wage survey has established the fact that a given occupation in a cooperating company matches one of the definitions, the next step is to ascertain the rate paid to each employee classified in that occupation. Actual rates must be determined since averages or ranges do not permit the analysis necessary to ascertain the prevailing slope. The individual rates should be identified as day-work rates or incentive earnings, and if the latter, they should cover a sufficient period of time to be reliable.

After enough companies have been visited to provide an adequate sample of the prevailing rates, the data for each of the occupations must be tabulated. This recapitulation should show the number of employees in each occupation who receive each rate. The weighted average or the median rate of the occupations should then be calculated. The median is preferable because it is less influenced by extremely high or low rates than the average. To test the representativeness of each average or each median, the highest and lowest fourths of the rates for each occupation should be eliminated in order to find the range within which the "middle half" of the rates fall. This range, known to statisticians as the interquartile range, is useful in delineating the middle half of the market. Once the sample of individual rates has been tabulated and analyzed in this manner, it is possible to construct a chart showing the prevailing or general level, i.e., the slope, of rates in the community in terms of the grades or ratings of difficulty, as illustrated by Figure 51.

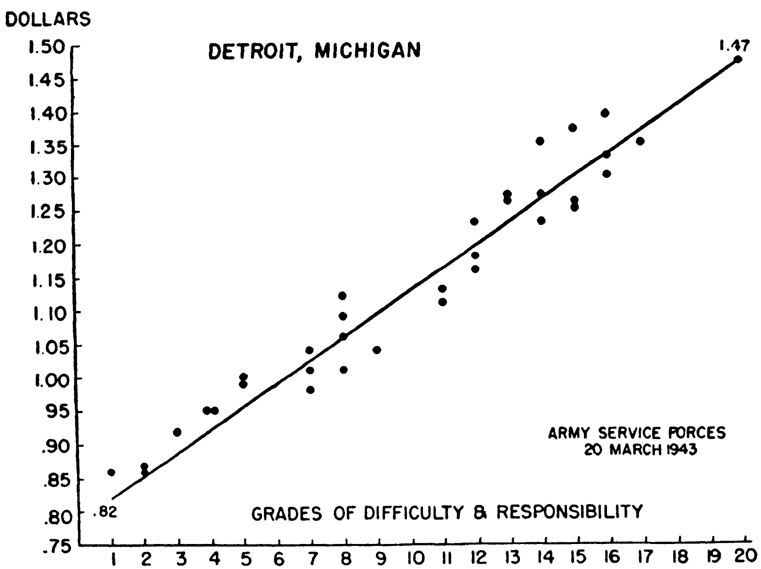

Figure 51. Slope of Market Rates. Adapted from Rating Guide developed by Wage Administration Section, Headquarters, Army Service Forces, Manual M 203, May 1945, p. 26.

If the internal alignment of rates, which is the primary purpose of job evaluation, is not to be distorted in the development of the final rate schedule, it is essential that the rate schedule should be determined with reference to a general slope and not to the average rates of specific occupations. The ratings of those occupations for which satisfactory data have been obtained are located on the base line of the chart. When the median or average rates of the market are plotted, the result will be a series of plottings that will fall reasonably close to a straight line or to a smooth curve. A free-hand line can be drawn through these points or, if the plottings seem to follow a straight line, the statistical procedure for ascertaining the line that fits them best is the method of "least squares." In either case the resulting line will show the central tendency of the data collected.

Various problems confront the analyst who seeks market data in connection with evaluation of supervisory posts. Companies have paid more attention to their hourly rates than their salary scales in relation to those prevailing in the community or industry. The definitions of many salaried positions are necessarily less clear-cut than those of hourly-paid jobs, except for routine salaried positions, e.g., comptometer operator. The scope of responsibility that affects the relative importance of the higher positions is not easy to define in terms that will facilitate the securing of comparable data from cooperating firms. The actual salaries paid frequently reflect the special abilities of the incumbents of the positions. The kind of supervision received and exercised in a given job and the amount of responsibility carried are difficult to reduce to precise language under any circumstances. Finally, executives' salaries seem to be influenced by the traditions or precedents of the company. The relationship of the executives at a given level of authority to those of subordinates on the level just below seems to follow patterns of long standing, and to differ even within departments of the same corporation. These relationships obviously affect any recapitulation of salaries collected from a number of companies.

Preparation of wage and salary schedules. Once a graphic picture has been obtained of the prevailing slope of rates paid in the community for the common occupations covered, the company faces the problem of deciding how its own general slope should be related to that of the labor market. In arriving at this decision, it must be remembered that a survey of community rates has definite limitations. It lacks comparability as to output and quality, to which reference has already been made, and the rates paid lack comparability because of variations in practice as to length of service, hours worked, favoritism, and the company's reputation as a place of employment.

In deciding whether a company's schedule should be centered upon the slope of prevailing rates, as in Figure 51, or should be placed above or below it, the management faces a conflict between the personnel and economic considerations involved. If a company's slope is placed too far above that of the market, its ability to compete may be endangered. If its slope is placed too far below, the company's ability to secure and hold capable employees may be affected adversely. Consequently, to keep its employees satisfied and its costs in line with those of competitors, it may decide that its own slope should be about the same as that prevailing in the community or in the same industry. Whatever its decision, sound personnel practice indicates that the steepness of a company's slope should approximate that of the market, in order that its skill differentials for more difficult occupations may be sufficiently liberal to induce younger employees to fit themselves for the higher occupations and to satisfy those who have already acquired these skills. A company's failure to use occupational differentials as generous as those in other plants is likely to cause skilled workers to feel that their status is not reflected in the pay envelope.

Another important consideration is whether hourly-paid occupations should be assigned a single rate or a range of rates. On certain work, such as that generally classified as unskilled labor, where it is difficult to determine accurately the performance of individual employees, a single rate for each occupation has the advantage of eliminating favoritism and guesswork. If this practice is followed, employees whose performance is consistently superior should be rewarded by receiving opportunities for advancement to higher paid jobs.

Even for semiskilled and skilled occupations the single job rate appears preferable if the kind of work done within each occupation does not vary and if the occupations can be defined clearly and precisely. Such a condition exists when the process and product are standardized. Management may feel, however, that employees with the same job title, who do the same general type of work should receive different rates to compensate them for differences in ability and performance. A range of rates for each occupation may be established in such cases, but the use of this method places a definite obligation upon management to see that the use of the ranges is controlled. Foremen and other supervisors ought not to be permitted, merely on the basis of their opinion and personal judgment, to recommend changes in their subordinates' rates within such rate ranges. To avoid favoritism and to assure employees that their rates are equitable, a systematic method is required for gaging the employee's performance, efficiency, and quality of work. The control over the application of rate ranges is also facilitated by the division of each range into a series of "step rates," each representing a definite number of cents per hour (see Figure 50).

Although the rate schedule for hourly-paid jobs may permit the use of a single rate or a rate range for each job, ranges should be used in constructing a schedule for salaried work. Rate ranges are essential in the case of salaried positions because of variations in the abilities of salaried employees. Except in the most routine office and engineering jobs, as, for example, typists who do copying only, the job limits are wide enough to take into account the differences in the native ability, training, interest and initiative of the incumbent, which will determine his contribution to the company. The minimum of each salary range reflects the compensation that can be earned by a worker who makes the least contribution that the position will permit.

The determination of the pay schedule involves two additional questions of policy. One concerns the differentials for the jobs of high skill, which provide an incentive to employees to acquire the skills needed and have a definite relation to the training program of the company; the other has to do with whether the company rates should be based upon those prevailing for individual occupations or upon the market slope for a series of occupations. If the supply of workers having a particular skill is scarce at any moment, a company that needs more workers in order to "get out its production" will, of course, raise certain of its rates in order to secure the requisite number of new men or to hold its existing work force. Such a practice should be confined to emergency situations since it does violence to the internal alignment that must be maintained for the sake of employee morale. The only sound general policy is to relate the company's wage scale to the general slope prevailing in the community as computed from a considerable number of common occupations, and when an emergency situation arises, such as described above, it should be made clear that any higher rates that are established as a result are "special" rates and are outside the regular rate structure as developed through job analysis.

Still another question of policy to be decided by top management is whether the company should price its hourly-paid jobs and salaried positions in such a manner that equivalent pay will be given for work of the same difficulty and responsibility. This is the time-honored question as to whether it is possible and expedient to keep the annual compensation of salaried and hourly-paid workers on a parity. Companies encounter this problem both when rates are being reduced and when they are being increased. Although it may be desirable from the point of view of employee morale to compensate these two groups on a similar basis during the early days of a depression or during periods of rapidly rising living costs, it does not follow that it is sound in the long run to attempt to use the same general curve for setting hourly rates and salaries. The demand for workers in these groups may vary greatly at different times; a management may want to extend its engineering development work at the very time when factory operations are heavily curtailed. Moreover, the office force, paid on a salary basis, and the factory force, paid on an hourly basis, are recruited from very different labor sources. The problem is also complicated by the fact that salaried employees may enjoy certain privileges that serve to make their annual earnings more secure than those of hourly-paid workers. Consequently, separate scales of rates for the two groups should be established in line with the labor market from which each group is recruited. The same line of reasoning would lead to the use of separate pay scales for male and female employees, except for those occupations in which both sexes do identical work. This argument for separate pay scales on the basis of sex is based upon differences in the demand for and supply of male and female labor.

A fourth question of policy, which applies to a company that has branches located in more than one community, has to do with geographic differentials. Here, again, there is a conflict between the economic and personnel aspects of rate setting. It is economically sound to establish a schedule for each plant based upon the prevailing rates in the community, since it permits a company to operate in low-wage locations, but at the same time to pay sufficiently high wages to attract and hold satisfactory employees. Such a policy, however, raises personnel problems if a company desires to transfer workers from one plant to another, because different rates may be paid for the same type of work in the various plants. Still another obstacle encountered in pursuing this policy is the position in a small community of a large employer. Since he plays a dominant role in establishing the prevailing rates, he cannot relate his wage scale to a general locality level.

Application of the schedule. When a rate schedule is being installed for the first time, the initial requisite is a table or chart indicating how the rate of each person on the pay roll compares with the rate schedule for his occupation. Such a comparison is frequently made before the schedule is adopted in order to calculate the cost of bringing the low rates up to the established rates or to the minima of the ranges. If the comparison shows that a number of individals are getting less than the minimum for their occupation, it is usually considered sound policy to increase the rates of these individuals as quickly as practicable. Although this step will involve some cost to the company, it must be taken if employees are to have confidence that the rate schedule will be administered equitably. Such increase in pay roll as may result is likely to be offset in whole or in part by improvement in employee morale.

The more difficult problem is to decide what to do about rates that are higher than those indicated by the schedule. It is generally believed inexpedient to reduce such rates immediately after the new schedule is adopted. Companies often justify the rates of overpaid employees by the explanation that the existing rates apply to the individual workers and not to the jobs they hold. It is made clear that others who are hired for these occupations will be compensated in accordance with the rate schedule and that the company will seek opportunities to transfer to more skilled occupations those whose rates are higher than the schedule. Frequently, companies improve the wage alignment when a general increase in wages takes place by not raising the wages of individuals who are overpaid. It must be recognized, however, that postponement of action in these cases is not wholly satisfactory from the standpoint of employee morale. Although the consideration extended to these overpaid individuals with long service may be pleasing to them, the fact that their salaries are out of line creates a general impression of unfairness.

Administration of wages after installation of rate schedule. The problems of administering wages with the aid of a rate schedule based on job analysis and evaluation are twofold—those associated with keeping the descriptions, evaluations, and schedule up to date, and those having to do with the application of the schedule to individual employees.

The situations requiring the assignment of a rate of pay to an employee are as follows:

1. Initial hiring.
2. A change from a lower to a higher job, or vice versa.
3. The discovery that an employee is incorrectly classified.
4. If rate ranges are used, an increase or decrease in an employee's efficiency.
5. The transfer of an employee from one location or department to another.
6. A general increase in the company's wage rate schedule.

As already indicated, the general direction of the job analysis program should be vested in an individual or group of individuals that can view the entire pay roll objectively and bring enough perspective to bear on the problem to keep the several departments in line with one another. In large companies with many specialized departments and plants, several committees may be required for effective administration of the rate schedule.

If the responsibility for administering the rate schedule is assigned to an interdepartmental committee, the director of industrial relations may well serve as a member. It is unsound policy, however, for the industrial relations director or his department to assume control of rate increases, because such a function would interfere with his proper role as staff adviser to the operating executives. In effect, this situation would transfer the responsibility for increases from the operating executives to the personnel department. The personnel department would thus be placed in the position of having to say "no" to requests for advancement that might be supported by operating executives because they felt free to "pass the buck" to the personnel department. It would be equally inadvisable for the director of industrial relations to have the primary responsibility for determining the place that a newly created job should occupy in the rate schedule or for making revisions in rate ranges that are in dispute. It is more sound for the industrial relations official to contribute his knowledge and suggestions through a committee composed of high-ranking executives from the departments affected.

The application of the rate schedule requires a periodic review of the performance of each employee. Some companies are content with annual or semi-annual reviews, but others, as for example, the Leeds and Northrup Company, review each case four times a year. Periodic review serves a number of purposes: (1) it enables a check to be made as to whether the actual work of each employee corresponds with his title on the pay roll; (2) it permits consideration of the question as to whether a worker is sufficiently capable to be continued in his present job or so valuable that he should be advanced to, or trained for, other work; (3) it enables the management to counteract the tendency for workers of ability to get trapped in "blind-alley" jobs; (4) it shows each individual that responsible executives watch his performance and progress, even in periods when actual promotion in job or pay is not feasible; and (5) if the rate schedule provides a range of rates for a given job, the review determines at what point between the minimum and maximum of the range an individual's rate should fall.

If a review of the type just described is to be sucessful, a technique should be worked out for making it systematic. Some device, such as a tickler file, may be used to bring up each employee's name at regular intervals, and an executive must be charged with the responsibility for seeing that the reviews take place according to schedule. A worker's performance should be considered by those in a position to know its quality, but it is advisable to have the participation not only of the worker's immediate "boss" and other superiors, but also of the personnel manager to insure that the action taken on individual cases is consistent with general policy.

Records are required for the proper conduct of these periodic reviews and should cover (1) output, (2) rejects and spoilage, and (3) versatility and attitude. Without records, too much reliance is placed on the "say-so" of the worker's immediate superior. Even if the superior is unbiased, his statements will be less satisfactory than actual figures.

Efficiency or output data become available whenever an operation is subjected to time study, but operations that are not repetitive do not lend themselves to such study. Consequently, information as to output can be secured in reliable form for the measurable occupations, such as milling and drilling, but not for unmeasurable ones, such as toolroom tending.

The quality of a man's work is more difficult to reflect in objective records than its quantity. Not all bad work is caught by the inspectors, and even if it is caught, the seriousness of the defect and the responsibility for causing it are not always easy to determine. In short, records of rejects and spoilage are considerably colored by human judgment.

The other human attributes that must be evaluated in determining a worker's contribution to his company must usually be appraised without the benefit of objective data. The chief exception is versatility, but even here a record will merely show how many operations the worker has demonstrated his ability to perform, rather than the number he could perform if given the opportunity. Workers are often prevented from becoming as versatile as they might be by foremen who keep them steadily on a job at which they are proficient. This problem may be solved eventually through the use of psychological tests.

In brief, the qualities to be appraised with respect to each individual may be grouped under four headings: quantity, quality, versatility and dependability. These imponderables are too important to ignore in deciding questions of individual pay raises and promotion. Consequently, many managements are adopting performance rating for securing the consensus as to each worker's performance, abilities, and potentialities. It must be emphasized that this form of rating applies to the worker, not to his job. It is merely an effort to make a systematic and impartial appraisal of matters that must be judged in some fashion whenever questions of promotion or layoff are being decided.

Performance rating is, therefore, an application to the individual of the philosophy that underlies job evaluation. It attempts to determine the quality of the individual's performance in relation to the demands of his job, and his fitness for the work in relation to the human attributes called for by the job. In addition, the part of a worker's contribution to the company that is affected by his attitude and personality ought to be appraised. An individual who is technically competent but difficult to work with may be less valuable in a team than one not so well qualified technically. Moreover, a worker's possibilities for growth affect his potential value. Although these considerations are not easily appraised, their evaluation in a uniform manner is a step forward. Performance rating applied consistently to all those covered by the rate schedule is, therefore, coming to occupy an important place in well-rounded plans of pay-roll administration.

Questions:

1. What are the characteristics of a good job description?

2. Should such descriptions be prepared by the employees themselves?

3. Are geographic wage differentials justifiable?

4. Are wage differentials based on sex justifiable?

5. Should the jobs of factory, office and technical employees be priced from the same wage "slope"?

6. The installation of a wage schedule reveals that the rates of certain employees fall above the evaluated rates for their respective jobs. What action would you recommend?

CHAPTER 25

Financial Incentives

A FINANCIAL incentive is compensation that is contingent upon measured performance rather than upon time worked (as under day work). For manual and clerical workers, performance is ordinarily measured in units of output, but quality bonuses are by no means rare. For salesmen, performance is measured by sales volume in dollars; for foremen and other supervisors, by savings in labor or material; and for top executives, by profits.

Why are incentives used? An executive is constantly faced with the problem of stimulating those working for him to do their best. One solution is financial incentives. Because they affect costs through productivity, incentives are an essential tool of general management; because they affect the amount of money in the pay envelope and the manner in which it is earned, they lie at the very root of personnel relations.

The answer to the question "Why are incentives used?" is relatively simple. Men usually do not work at their capacity unless they are stimulated financially. Perhaps a more accurate statement is that managers have found by experience that workers are not likely to maintain their maximum efficiency over long periods unless they are compensated according to their performance. By emotional appeals or driving, management may secure 80 per cent or 90 per cent efficiency without the use of direct incentives; but some extra output can be secured only by an appeal through the pocketbook. What is equally important to management is that a financial incentive tends to act as a ratchet to keep efficiency from retrogression when the management's attention is diverted to other problems. Wage incentives are used, also, because they reduce costs. Labor costs are reduced directly by increased efficiency; fixed overhead per unit is reduced indirectly by greater output per machine hour.

Theoretically, the performance of the worker ought to be stimulated in two directions, output and quality. Although incentives are installed to accomplish both results, those designed to stimulate output alone are by far the more numerous. It has been discovered that in plants where workers are paid flat hourly rates, they are likely to be not more than 50 per cent as efficient as they become after their operations have been improved by time and motion study, and they are paid extra compensation according to what they do. Consequently, it may be said that the joint result of improved management and of the financial stimulus is approximately to double efficiency. If it is a fair assumption that day work efficiency is only 50 per cent of that attained under incentives, properly installed and administered, then it is clear that their use results in substantial labor saving. The labor cost will not be halved, however, because part of the saving is paid to the workers as bonuses.

It is difficult to appraise the effects of financial incentives alone, since their installation is always accompanied by management changes. There are cases where office routines and costs have been improved almost as much by careful analytical study as might have been expected if incentives had been used in addition. For example, as a result of an analysis of the process and of a time study of the operations, a bank department engaged in the sorting and listing of checks was found to be about 50 per cent efficient. Within the year this efficiency had risen to between 85 and 90 per cent over monthly periods, and on many days reached 100 per cent. The gain is to be accredited to management, because it was secured by analytical study and experimentation, rather than by an increase in the pace of the workers. Because of unevenness in the flow of work, time had been lost between operations, and because of unevenness in the volume of work, there had been at times an excess of man power. The batches of checks sent through the operation were too small for maximum efficiency.

Among the steps taken as a result of the study were the provision of work that could be used as a backlog in dull periods, the improvement of the workplace and of methods used on the key operation, the adjusting of the number of men more closely to the volume of work, and the training of the slowest operators. In addition, the size of batches was standardized at the point where the total time needed for the entire operation would be at a minimum. Obviously, the larger the batches, the less time is lost in the preparatory work on each one; but the smaller the size, the easier it is to correct errors. Although the employees were well paid in comparison with similar workers elsewhere, they were at no time paid a financial incentive.

One might easily argue that management has an obligation to provide incentives, wherever practicable, in order to be fair to the employees who work hardest. Although many union leaders urge flat hourly rates because such rates facilitate collective bargaining, the majority of fast workers like extra pay for their superior skill and larger output. From the standpoint of such individuals, it seems only fair that greater productivity should command higher earnings. A man's effort and skill reflect his own initiative, and industrial managers have the opportunity, and perhaps the obligation, to bring to bear upon him influences that will spur him on to do his best. A money reward is therefore a useful tool of management, because it is at once a concrete measure of performance and a recognition of the worker's contribution.

The question is often asked why a company should pay extra compensation to its workers when they are hired on the theory that they will do their best. It is even implied occasionally that the offer of an extra reward carries with it some implication that workers have been "holding out" on the company. The best answer to this question is that workers do "hold out" both unconsciously and consciously: unconsciously, when their initiative is not stimulated; consciously, when they have a feeling of unfairness that extra effort on their part is unrecognized and unrewarded in any tangible fashion.

Management's role. Incentives are not a panacea. Consequently, incentives should not be installed until management has explored the opportunities for cost reduction through improved management and has brought under control the factors affecting performance other than the worker's effort. The management problems incident to the installation and use of incentives are infinitely more important than the mathematical analysis of the impact of a particular plan upon unit costs and employee earnings. Incentives should be looked upon as a capstone for management's efforts to improve efficiency and to reduce costs by research and closer control of materials, methods, equipment, and workers.

Prerequisites of incentive for rank-and-file.

1. The work must permit measurement of the performance rendered, and the task times or other standards of performance must be uniformly difficult to attain.

2. The factors that affect output, other than the operator's skill and effort, must be brought under reasonable control by management. These factors include the steadiness of the flow of work, the size of the lots worked on, the quality of product, the quality and uniformity of the raw materials, and the condition of the machines and equipment.

3. The counting and record keeping of output and the actual time worked must be accurate.

4. Inspection must be sufficiently effective to determine whether or not the quality of the output upon which incentives are based is satisfactory.

5. Employees placed on incentives must be assured of protection against "rate cutting." The latter means changes in piece rate, task times, or quality demanded that will require

the employees on incentive to work harder to earn the same pay.

Characteristics of a good incentive plan for rank-and-file employees.

1. The plan should be understood by the employees, and it should offer sufficient incentive to be attractive to them.
2. The units used in measuring performance should accurately reflect the effort expended.
3. The incentive earnings should be paid promptly after the end of the period during which they are earned.
4. The employees should be given guaranteed base rates equivalent, at least, to what they would earn on a day work basis.

The structural design of the incentive plan should be determined only after consideration of certain basic questions:

1. How high should the incentive differential be?
2. Should the company give the workers all of the labor savings above a certain point, or should it share them with the employees?
3. How high should the level of efficiency be that is adopted as standard?
4. Should the incentive plan be based upon individual or group performance?

How high should the incentive differential be? This question deals with the difficult psychological problem as to how large an incentive is needed as a stimulus. Obviously, the percentage is affected by the amount of the base rate and by the amount of bonus that the worker is enabled to earn. This, in turn, depends not only upon the difficulty of the task but also upon the assistance provided by management in the form of proper tools, and so forth, as well as upon the generosity of the payment system.

When financial incentives were first employed, it was assumed that faster-than-average workers should earn more than the customary day rate for the type of labor they performed. F. W. Taylor advised additional earnings of 30 per cent to 100 per cent of the day rate.

It must be clearly recognized that the inducement offered to the workers is affected by the level of efficiency at which the task is set. If the task is made easier to attain and to excel, the amount of incentive is increased. Moreover, the spur that the bonus exerts depends on the ratio of the guaranteed rate to the anticipated hourly earnings. The hourly earnings, in turn, are influenced by the difficulty of the task to be accomplished, as well as by the economic factors affecting the labor market.

It is not true, however, that there is any simple relationship between the amount of money paid and the impetus created. Twice the money does not produce twice the effect. Individuals differ so in their attitudes and objectives that their response to extra earnings varies tremendously. What the effect will be depends upon temperament and the relation of the income to a man's customary standard of living. The fact that workmen in the South will "lay off" if they are paid too generously has become a stock story in wage discussions. On this issue, the pros and cons may be summarized by the statement that steadiness weakens an incentive, but makes it more attractive to those workers who value security above adventure. Also, it is important to recognize that an incentive can be so small as to cause the recipient to turn against it. Perhaps the soundest concept is that embodied in the following quotation from Henry S. Dennison:

> There is a sort of Gaussian curve to the amount of incentive: there is a minimum below which it is no incentive whatever and a maximum above which it starts up so many other influences that its effect as an incentive to active and energetic work is smothered. The greatest good per dollar lies in the middle ranges. . . .[1]

[1] Henry S. Dennison in the *American Management Association Bulletin,* 1928, Annual Convention Series, No. 71, page 10.

Should labor savings be given entirely to workers, or shared? Gains from increases in efficiency between the old day-work level and the point at which extra-compensation starts under the incentive plan are retained by the company entirely. Many companies have decided, as a matter of policy, that any payment plan used must pay out all the labor savings to the workers once the workers begin to earn more than their guaranteed rate. Such a policy is followed, often unconsciously, by companies that use piece rates. The decision has merit when the products and methods are highly standardized, and when the operations are repetitive. Under these conditions, precise time-study work is possible, and, in addition, the factory overhead is likely to be high because of mechanization. There are possibilities here for savings in total cost far in excess of those in labor cost. For these two reasons, it is entirely feasible for such companies to distribute in bonuses all of the labor saving above a given efficiency.

In contrast to the companies that make their bonuses equivalent to the labor savings, are the companies that divide the labor savings between the company and the employees. If the work is not highly standardized and precise time studies are not possible, the task level is likely to be low. In such circumstances companies feel that it is "safer" to make the bonuses less than the labor savings.

There is another significant argument for the division of labor savings. If a company in a highly competitive industry pays out in bonus the entire labor savings, its labor cost is the same no matter how high the efficiency of its workers may rise. With its labor cost pegged in this fashion, the company may feel an urge to cut rates, a temptation sometimes too strong to resist. If such a development is likely, it may be fairer to the workers in the long run to start the bonus at a lower efficiency and to divide the savings so that employer and employee both continue to benefit as efficiency rises. This plan reduces the likelihood that the earnings on a particular job will become so much out of line as to attract the eye of some hard-boiled executive, and reduces the temptation to "cut."

Difficult versus easy task level. The relation of the general task level to present and maximum efficiency is discussed infrequently in the literature describing actual plans. The answer is affected by the following factors:

1. The degree to which close managerial control over operations and operating conditions can be maintained.
2. The existing efficiency of the employees and the ability of the management to increase their efficiency.
3. The psychological effect upon the worker. It is believed that workers should "beat" the task rather than fail to reach it. If the task level is either too high or too low, it will tend to discourage improvement.
4. The share of the saving in labor cost paid to the workman under the wage payment system or curve adopted.
5. Technical factors taken into account in setting the task level, such as the method of leveling and the exclusion or inclusion of an "incentive allowance" in the task times. Such inclusion, though encountered in practice, does not seem to be good practice.

Managerial control is likely to be precise in industries where manufacturing is continuous by nature, or in assembly industries, such as the automobile, which have made the manufacturing operations continuous. In these concerns, the number of factors that cannot be stabilized is relatively smaller than in enterprises manufacturing a variety of products to customer's order. Consequently, emergencies and unusual situations can be controlled more closely and the time-studied task can be set more accurately. In such a situation it is possible to locate the task near maximum efficiency and to pay a high reward for attaining it.

A practical problem that must be faced before the task is set is that of deciding how the efficiency is to be raised above the existing level. In general, two methods are adopted, either independently or in combination. One is to take the plant, department by department, and to raise the efficiency of each department by the energetic and concerted attention of the management. The company assumes the full burden and takes the entire gain. If this plan is adopted, it is important to introduce it in a department that can be brought up to the task without too much difficulty. This method will avoid the danger, which a large company encountered, of choosing the hardest department for the first installation. Although the plant finally succeeded in getting this department up to standard, the path would have been smoother had it begun in an easier spot.

In contrast to this method of administrative "shoving," the arrangement provided by the Emerson and the Wennerlund curves leads the employees along by small financial inducements that begin at 67 per cent and 75 per cent efficiency, respectively. In both cases, these bonuses increase in amount as the efficiency approaches 100 per cent. The idea behind these plans is that after the employees have received a small bonus, the incentive to increase that bonus will lead them along to higher and higher efficiencies. The same thought may be said to underlie the Halsey and the Rowan systems, as they place the task so low that employees can begin earning a bonus at a low efficiency.[2]

Individual versus group incentives. The term "group incentives" means compensation that is based on the combined output of a number of workers. If their work is closely related, employees can do much to help or hinder their associates, and the logical basis for paying them extra compensation is to use their combined performance. The use of group incentives has developed because modern manufacturing methods have tended to link jobs together. Their resulting interdependence provides the *raison d'etre* for group incentives because, if work is supposed to flow continuously from

[2] C. C. Balderston, *Group Incentives*, page 46. Philadelphia: University of Pennsylvania Press, 1930.

one worker to another, the speed of a given employee depends upon that of his predecessors in the line. Consequently, it may be said that in situations to which they are adapted, group incentives tend to develop teamwork and to minimize self-interest. It should be emphasized, however, that such incentives should not be applied unless the jobs are interrelated. Neither are they suited to operations on which the number of workers and the production schedules change violently or continually.

Perhaps the extreme example of interdependent work is to be found in so-called linear or progressive manufacture. In a rolling mill or a forge shop the individual output cannot be isolated, and if an incentive is to be used at all, it must be based upon the output of an entire gang. Not only does inability to measure individual performance force the use of group rather than individual incentives in such cases, but group incentives perform a definite function in keeping the operations in balance. Such a balance is especially hard to maintain when the rate of production is changed. Therefore, an inducement is needed for the men to move to the spots where work is accumulating when they have nothing to do at their regular stations.

Group incentives are also better than individual ones for indirect labor (that is, labor that changes neither the form nor shape of the product, and the cost of which cannot be directly applied to specific units). One class of indirect labor comprises jobs that are in close association with direct workers. It includes set-up men, crane operators, handlers, truckers, and inspectors if the inspection is a matter of routine and can be treated as a production operation. Another class is that which is separated from the direct-labor operations, but in which tasks are definable and in which accomplishment can be measured. Work of this type is found in operations such as the receiving of materials and the shipping of the finished product, and may be clearly observed in the shipment of automobiles, packing-house meat, and barrels of oil. In contrast, for a certain type of indirect labor, such as that used in the maintenance of machinery, it is extremely difficult to predict how long the work should take and to compare the results with a predetermined standard.

Individual incentives represent a strong spur to action, but they tend to destroy cooperation among employees. They are strong because a worker is rewarded for his own success and penalized for failure. No one shares his gains or his losses. Yet they provide no inducement to the employee to cooperate with his fellows beyond that degree which he thinks will further his own interest. They not only permit but encourage competition of workers with one another.

Individual incentives tend to destroy teamwork because it is to the interest of each individual to increase his own output, even at the expense of those around him. The experts guard the secrets of their trade instead of teaching them to others. They maneuver to secure the "softest" jobs and those with the greatest money-making possibilities. The slow workers, on the other hand, feel resentful toward the high producer. Even if the company follows the policy of not cutting rates, the slow employees instinctively fear that the star worker may be endangering the rates if his daily earnings grow too large. The result is that those who have less than average ability tend to bring pressure upon the fast workers, in order to restrict their output. When individual incentives are used, unity within the group can be developed only in the face of the emphasis upon individual self-interest.

In contrast, a group incentive is obviously a weaker stimulus because it is possible for a man to "lie down" and to let the other members of his group carry him. This tendency on the part of irresponsible workers is partially offset by the pressure of the other members of the group, if the group is small. Sometimes group incentive operates harshly in that the older members of the group ask for the removal of a newcomer if they think he is slow and inefficient. It may, however, influence each member of a group to aspire to win the regard of his fellows. In addition to seeking the good will of the others by increasing his own contribution to the team, he may offer constructive suggestions for the conduct of their work.

The answer to this problem should rest primarily upon the nature of the work, that is, whether the jobs are independent or interrelated. But when teamwork is necessary for effectiveness—as in the case of a book department of a department store, where customer contact must be maintained—the management should fully consider all the implications. These may be summarized as follows.

Group incentives are a direct motivating influence in developing teamwork and group spirit. Since the members of each gang have a common objective, the premium placed upon team play has great social significance. Also, group compensation provides a constant interest in the results attained, and at the same time builds up the morale of the force because it recognizes the interdependence of those in the group. It encourages the worker to greater accomplishment, but it means that his advancement can be secured only as a member of a team and not as an individual working for selfish interests alone.

Group bonus is an important device of management, but it is not a panacea. Properly installed, it provides an incentive to increase the joint output and to maintain satisfactory quality, and the adjustment of base rates to reflect effort and ability provides individual stimulation within the group incentive. It captures the interest and enthusiasm of the team and, like other incentives, appeals to those who believe in a philosophy of leadership as contrasted with "driving." Perhaps the great significance of group incentives is that they emphasize teamwork and cooperative effort rather than self-interest.[3]

In the decision of the proper size and composition of the group, the test is the degree to which its members can be

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[3] C. C. Balderston, *Group Incentives*, page 28. Philadelphia: University of Pennsylvania Press, 1930.

mutually helpful. This factor depends upon the interdependence of the jobs and upon the opportunity for the men to assist one another. The smaller the group, the greater is the stimulus felt by each member. Consequently the groups must be kept small if a strong incentive is desired. Many managers favor groups of fifteen or twenty men; ordinarily the number of men in a group should not exceed forty. However, in the past, some companies have exceeded this figure in order to reduce clerical expense of counting production.

At the opposite extreme from individual incentives are plant-wide incentives. These are really group incentives in which the group contains the entire work force. Though there are instances in which such incentives have appeared to increase production, especially where the product was reasonably homogeneous, they violate the tests of a good incentive. They are not based on carefully standardized operating conditions, and the unit in which plant performance is measured does not reflect effort accurately.

Types of payment plans. The mathematics of so-called incentive systems involve only simple arithmetic, yet any attempt to delve deeply into the various plans results in tables and charts so formidable that the real essentials are often hidden. Reference has already been made to the fact that some incentives are related to profits; some to savings against the budget; and some (and these are far more frequent) to the quantity of output. A few are based upon the quality of the work done.

In actual practice incentive plans are identified by a variety of names. The design of all of them can be altered by changing any one of five factors: task level, base rate level, incentive differential, point at which extra compensation exceeds the base rate, and the percentage of the labor saved above that point which is paid to the employee. Although the variations from each of the following plans are numerous, a single version of each is presented to show how earnings are computed. It is also important to analyze the effect of each one on unit labor cost and unit total costs.

Standard-hour plan. Under the standard-hour plan, the allowed time is expressed in man-hours. This allowed time is considered to represent 100 per cent efficiency. If the actual time of the employee is less than the time allowed, he is paid the saved time as a bonus; if the actual time is greater than the time allowed, the employee receives his base pay. The employee is paid a 1 per cent bonus for each 1 per cent gain in attained efficiency over 100 per cent. The attained efficiency equals the allowed time divided by the time taken.

This plan has reasonable simplicity, plus the distinct advantage of using the same time standards employed in production planning, budgeting, and estimating of selling prices. If the bonuses are based on attained efficiency, this method furnishes to management, as a by-product of the incentive plan, a running record of individual and departmental efficiencies.

When attained efficiency is *above* 100 per cent:

Earnings equal attained efficiency times hours worked times rate per hour.

Or, earnings equal allowed man-hours times the rate per hour.

When attained efficiency is *below* 100 per cent:

Earnings equal the number of hours worked times the rate per hour.

Example:

Task time for job	= 10 hours.
Employee's base rate	= \$1.20 per hour.
Time taken	= 8 hours.
Efficiency	= 125 per cent.
Employee earnings	= 1.25 × 8 × \$1.20 or \$12.00.
or Employee earnings	= 10 × \$1.20 or \$12.00.

Piece rates. Under piece work, a definite price is announced for each job. This price is determined by multiplying the task time by the base rate. For example, if the task time equals 0.1 hour and the base rate \$1.20, the piece rate is

$0.12. Perhaps the strongest argument for piece rates is simplicity, for operators have no difficulty in understanding how their pay is computed. The use of piece rates, however, does not provide the management with a reliable measurement of individual efficiencies. These may be attained through supplementary records, but they are not provided as a by-product of the incentive plan itself, as is the case with bonus and premium plans. Moreover, since the base rate is used only when there is no piece work to do, or when there is a breakdown, it does not give the management an adequate opportunity to recognize such intangibles as loyalty, attendance, cooperation, and versatility.

When earnings for any given period are *above* the guaranteed rate:

Earnings = number of units produced × rate per unit.

When earnings for any given period are *below* the guaranteed rate:

Earnings = number of hours worked × rate per hour.

Example:

Task time for job	= 0.1 hour (i.e. 10 pieces per hour).
Employee's base rate	= $1.20.
Time taken	= 8.0 hours.
Units produced	= 100.0 pieces.
Employee earnings	= 100 × $.12 or $12.00.

The gain-sharing plans. This classification includes certain premium plans, such as the Rowan and Halsey schemes, which are among the oldest incentive systems. The Rowan premium divides the labor saving between employer and workers, and the premium equals the ratio of the time saved to the time allowed.

If the actual time is *less* than the time allowed:

$$\text{Premium} = \text{hourly rate} \times \text{actual hours} \times \frac{\text{hours saved}}{\text{hours allowed}}.$$

Earnings = hourly rate × actual hours + premium.

If the actual time is *greater* than the time allowed:

Earnings = actual hours × hourly rate.

Example:

Task time per job $= 10.7$ hours.
Employee's base rate $= \$1.20$ per hour.
Time taken $= 8$ hours.
Employee's premium $= \$1.20 \times 8 \times \frac{2.7}{10.7}$ or \$2.42.
Employee's earnings $= \$1.20 \times 8 + 2.42$ or \$12.02.

The computation of the Halsey premium plan differs from the Rowan plan in that the premium paid is a definite percentage of the time saved, multiplied by the individual's base rate.

If the actual time is *less* than the time allowed:
Premium = hourly rate × hours saved × premium percentage.
Earnings = hourly rate × actual hours + premium.
If the actual time is *greater* than the time allowed:
Earnings = actual hours × hourly rate.

Example:

Task time per job = 12.0 hours.
Employee's base rate = \$1.20 per hour.
Time taken = 8.0 hours.
Employee's premium \$1.20 × 4 × 50 per cent = \$2.40.
Employee's earnings \$1.20 × 8 + 2.40 = \$12.00.

These two premium plans were "sold" to employees with the understanding that if they could make a labor saving, the company would share it with them. The employer would inform the worker that he was taking a certain amount of time for the job and would promise to pay him a third to a half of any time he could save.[4] Thus the fact that the worker's premium is only a portion of the labor saving contrasts with piecework, which gives the employee the entire labor saving; that is, if the employee works twice as fast, he saves half the time and earns twice as much.

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[4] When the standards are based on past performance, the saving is often split between the company and workers on a two-third—one-third basis; but when they are established by time study, a fifty-fifty split is more common.

These gain-sharing plans have the disadvantage of being too complex. Although the plans can be described in simple language, it is far from easy for a worker to figure at the end of a day (or week) how much he has actually made. Moreover, the fact that the savings are divided, or, as the worker would put it, that the company keeps back part of the labor saving, is likely to produce an unhappy effect upon the worker's mind. However, executives have sometimes favored these gain-sharing plans during the transition from day rates to other incentive plans.

Plans that are designed empirically. Between the two extremes of giving to the worker the entire labor saving that results from increased efficiency and giving him only a fraction of it, are a number of plans designed empirically to produce certain desired effects upon labor costs and earnings. Typical of this group are the Emerson and Wennerlund plans, under which the bonuses start at 67 per cent and 75 per cent efficiency, respectively. For efficiencies just above the starting point, the bonuses are exceedingly small. In both plans, they amount to 10 per cent of the base pay for an efficiency of 90 per cent. At 100 per cent efficiency, the bonuses equal 20 per cent of the base pay. Above this point, the Emerson plan is so designed that it divides the labor saving between the employer and the workers, whereas the Wennerlund plan gives the entire saving to the workers in bonus (see Table 11 and examples).

If efficiency is *above* 67 per cent:

Bonus earned = actual hours × hourly rate × bonus percentage.

Earnings = (actual hours × hourly rate) + bonus earned.

If efficiency is *below* 67 per cent:

Earnings = actual hours × guaranteed hourly rate.

Table 11.

EMERSON AND WENNERLUND BONUS PLANS

EFFICIENCY IN PERCENTAGE OF TASK	BONUS IN PERCENTAGE OF BASE RATE	
	EMERSON EFFICIENCY BONUS PLAN	WENNERLUND BONUS PLAN
66.7	0.00	
67	0.01	
68	0.04	
69	0.10	
70	0.20	
71	0.35	
72	0.55	
73	0.75	
74	1.01	
75	1.31	1.0
76	1.61	1.6
77	1.99	2.2
78	2.39	2.8
79	2.80	3.4
80	3.30	4.0
81	3.80	4.6
82	4.34	5.2
83	4.95	5.8
84	5.55	6.4
85	6.23	7.0
86	6.93	7.6
87	7.63	8.2
88	8.40	8.8
89	9.20	9.4
90	10.00	10.0
91	11.00	11.0
92	12.00	12.0
93	13.00	13.0
94	14.00	14.0
95	15.00	15.0
96	16.00	16.0
97	17.00	17.0
98	18.00	18.0
99	19.00	19.0
100	20.00	20.0
100-UP	PLUS 1% FOR EACH 1% GAIN IN EFFICIENCY.	PLUS 1.2% FOR EACH 1% GAIN IN EFFICIENCY

Example:

Task time per job	= 8.4 hours.
Employee's base rate	= $1.20 per hour.
Time taken	= 8.0 hours.
Employee's efficiency 8.4 ÷ 8.0	= 105 per cent.
Employee's bonus percentage (see table)	= 25 per cent.
Employee's bonus $1.20 × 8 × 25 per cent	= $2.40.
Employee's earnings $1.20 × 8 + $2.40	= $12.00

The Wennerlund bonus plan pays a minimum hourly rate for efficiencies less than 75 per cent of the task; above 75 per cent efficiency, the percentage of bonus to be added to the guaranteed rate is determined from the Wennerlund curve. This curve resembles the Emerson in that it provides small but increasing bonuses to encourage the workers to attain 100 per cent efficiency.

If efficiency is *above* 75 per cent:
Earnings = (actual hours × hourly rate) + percentage of bonus earned.
If efficiency is *below* 75 per cent:
Earnings = actual hours × hourly rate.

Example:

Task time per job	= 8.32 hours.
Employee's base rate	= $1.20 per hour.
Time taken	= 8.00 hours.
Employee's efficiency 8.32 ÷ 8.00	= 1.04 per cent.
Employee's bonus percentage (see table)	= 24.8 per cent.
Employee's bonus $1.20 × 8 × 24.8 per cent	= $2.38.
Employee's earnings $1.20 × 8 + $2.38	= $11.98.

The chief disadvantage of these plans is lack of simplicity, which makes it difficult for workers to figure their pay. These plans have been widely used, however, and this disadvantage has been often overcome, at least in part, by furnishing the workers with a bonus table, together with periodic reports, from which they can compute their earnings and check the accuracy of the pay-roll department.

Plans in which the extra compensation starts or jumps suddenly. In contrast to the plans just mentioned, which offer a very small but gradually increasing reward starting at a low efficiency, are certain plans that provide a sharp differential between one rate and another. Perhaps the best-known of this type is the Gantt task and bonus, under which a worker is paid merely his base rate until his efficiency reaches 100 per cent. The moment it reaches this point, however, he receives a bonus of, say, 20 per cent, and for all higher efficiencies he receives the entire labor savings, very much as if he were on piecework.

Unlike piecework, the Gantt task and bonus plan introduces a definite task to be done, and expresses it in hours allowed per unit of output. For the attainment of this task, a bonus, often 20 per cent of the guaranteed hourly rate, is paid. If the task is just attained, the earnings are then 20 per cent higher than if the employee is only 99 per cent efficient; consequently, there is an abrupt rise in earnings when the employee reaches 100 per cent efficiency. If the performance is better than the task set, the earnings equal the number of hours allowed multiplied by the guaranteed rate per hour increased by the incentive differential percentage.

If the task *is* attained:

Earnings = hours allowed × (rate per hour + incentive differential percentage).

If the task *is not* attained:

Earnings = actual hours × rate per hour.

Example:

Task time	= 8.33 hours.
Employee's base rate	= $1.20 per hour.
Time taken	= 8.00 hours.
Incentive differential	= 20.0 per cent.
Employee earnings ($1.20 + $.24) × 8.33	= $12.00.

Bonus or premium plans based on points. In most of the point plans, a point represents the work done during one man-minute. The basic idea is to secure a common denominator in which the performance standards can be set for all types of work, involving both direct and indirect labor. It also serves as a unit in which actual production can be recorded and paid for. Once the standard number of points is established for each job, the company can use the same common denominator for planning the future production of each department, for measuring the actual efficiencies of each individual and group, and for remunerating them accordingly.

The Bedeaux point system has a common unit, the *B*, for measuring human effort. The *B* standard corresponds to the minutes needed by an average person, working under existing conditions at a normal rate of speed and effort, to perform an operation correctly. The number of *B* units produced per hour is the measure of individual, departmental, or plant accomplishment. For accomplishing less than sixty *B*'s per hour, a guaranteed rate is paid. For each *B* in excess of sixty per hour, a premium is paid. The premium for each extra *B* is obtained by dividing the base rate by sixty. Sometimes only three-fourths of this premium is paid to the direct workers, the remainder being reserved for the supervisors and indirect workers, but in the following example, it is assumed that the premium is not so divided.

If output *exceeds* 60 *B*'s per hour:

Bonus $= \dfrac{\text{hourly rate}}{60} \times$ premium points (that is actual hourly *B*'s $- 60$).

Earnings $=$ actual hours $\times$ (hourly rate $+$ bonus).

If ouput is *less* than 60 *B*'s per hour:

Earnings $=$ actual hours $\times$ hourly rate.

Example:

Task	$= 600$ *B*'s.
Employee's base rate	$= \$1.20$.
Time taken	$= 8.0$ hours.
Actual hourly *B*'s $600 \div 8$	$= 75.0$.
Bonus $\dfrac{1.20}{60} \times (75 - 60)$	$= \$.30$.
Employee earnings $8 \times (1.20 + .30)$	$= \$12.00$.

Measured day work. Although payment on a straight time basis, such as a flat hourly rate that remains unchanged regardless of fluctuations in production, can scarcely be called an incentive, there are modifications that do represent a valuable type of incentive, and that may be described as a series of hourly rates or salaries graduated to conform to changes in the worker's performance. These may be thought of as a flight of stairs which a worker ascends or descends periodically, according to his performance record of a preceding period. If he does better work, his rate advances; if poorer, it declines. If the worker's position on these steps is determined automatically and objectively rather than by the favoritism of the foreman, then differential rates may be used with success. Obviously, the more reliable the production records, the more successful the incentives are likely to be.

Reserved until last is a discussion of the hybrid plan known as measured day work. This is merely the combination of day-work rates that are adjusted periodically with attained performance, based upon output, quality, versatility, and dependability. Attained performance is measured against standard task times. As his efficiency rises, so does the rate assigned to the individual employee; as it falls, the base rate, theoretically at least, is reduced. The opposition and resentment of those whose base rates are reduced presents administrative difficulties that militate against the use of this seemingly simple plan. Its most useful applications perhaps are in transitional situations in which an incentive is desired but which are not ripe for the installation of a full-fledged plan such as the standard-hour plan.

Nonfinancial incentives. Financial incentives will not operate with complete success unless the management applies nonfinancial incentives also. Less tangible, these provide the spirit that gives financial incentives much of their life, since they influence the emotions and attitudes.

Nonfinancial incentives are formal arrangements announced to the employees in advance that are designed to increase employee performance by appealing to their attitudes and emotions. Unlike financial incentives, these plans do not link

Table 12

COMPARISON OF INCENTIVE PLANS

	Standard Hour Plan	Piece Work	Gain Sharing Plans		Empirical Plans		Gantt Task and Bonus	Bedeaux
			Rowan Premium	Halsey Premium	Emerson	Wennerlund		
Employee's hourly base rate	$ 1.20	$ 1.20	$ 1.20	$ 1.20	$ 1.20	$ 1.20	$ 1.20	$ 1.20
No. of good pieces finished in 8-hr. day	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Task time per piece (hrs.)	0.1	0.1	0.107	0.12	0.084	0.0832	0.0833	0.1[1]
Task time (hrs.)	10.0	10.0	10.7	12.0	8.4	8.32	8.33	600.0 "B's"
Time taken (hrs.)	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Piece rate	....	$ 0.12	....	....	....	....	....	....
Efficiency (%)	125.0	....	125+	....	105.0	104.0	104.1	75.0 "B's" per hr.
Bonus or premium in % of base	25.0	....	25+[2]	....	25.0	24.8	20[3]	25.0
Bonus or premium for 8-hr. day	$ 2.40	....	$ 2.42	$ 2.40[4]	$ 2.40	$ 2.38	$ 2.40	$ 2.40
Employee's earnings for 8-hr. day	$12.00	$12.00	$12.02	$12.00	$12.00	$11.98	$12.00	$12.00

[1] 6 B's [2] 2.7 ÷ 10.7 [3] Usually set at 20% [4] 4 hrs. ÷ 2 x 1.20

compensation directly with performance. These plans, relying upon competition among individuals and groups or their desire for status and recognition, may take the form of prize contests, honors, and awards for excellence.

The concept of nonfinancial incentives has been given impetus by the experiments of Mr. Robert Wolf in the paper industry. He took advantage of the human desire to improve and to participate, and stimulated that desire by making available to employees information concerning output, quality, and maintenance costs. The frank revelation of figures often considered confidential by management stimulated the employees to improve in precisely the manner indicated by Mr. Frederick W. Taylor in his discussion of definite tasks.

If a scheme is to make effective use of the competitive urge, it must be well formulated and made known in advance. Thus a contest among salesmen that is made known to them before the beginning of the period would qualify, even though prizes or awards were given only to the most successful ones. Herein lies a distinction between nonfinancial and financial incentives. Financial incentives provide some additional compensation for all who are eligible for incentives, provided their performance is sufficiently good to merit a payment in excess of the base rate. A financial incentive that did not yield some bonus or premium to the majority of the employees would not be considered a success, whereas, in a prize contest, the participants understand in advance that the number of awards is limited.

For nonfinancial incentives to come into their own, they should meet certain criteria:

1. There must be a definite plan, announced in advance, and simple enough to be understood.

2. The plan must operate automatically and consistently, unaffected by personal whim and bias.

3. The scheme must not be used as a substitute for money wages.

4. The plan must use appeals to which the particular employees will respond.

5. The same appeals should not be used so long that the worker's interest wanes.

It is important to recognize the distinction between interest, which is the basis of nonfinancial incentives, and the money motive. Money motive, even though it results in increased production, may not increase interest. It is a reward that lies outside the job, whereas interest is "the sense of a total self-expressive relationship of worker to the work." Both types of incentive are essential parts of a program designed to secure adequate response from the man on the job.

Questions:

1. Appraise the soundness of a "no-smoking" bonus; of a bonus for maintaining the "standard of a good workman."

2. Is it fair to deny a no-accident bonus to a truck driver whose truck is hit while parked legally?

3. Appraise the soundness of a plant-wide incentive based upon the volume of shipments in dollars; on the volume of goods produced measured in physical units.

4. How would you determine the size of the incentive differential?

5. If one-half of your employees perform work that does not lend itself to incentives, would this fact deter you from using incentives for the other half?

6. Would you extend the application of incentives to:

(a) Inspectors?

(b) Sweepers?

(c) Machine repairmen?

7. Suppose the plant were half idle; would there be an actual saving in overhead by increasing the output of one of the machines that was being operated?

8. In deciding upon the composition of a group under group incentives, would you include truckers? crane operators? sweepers? foreman?

Section X

INDUSTRIAL RELATIONS AND LABOR RELATIONS

CHAPTER 26

Industrial Relations and Labor Relations

IN many respects the management problems encountered in obtaining, utilizing, and maintaining an adequate working force are similar to those met in handling the other factors of production. The types of workers needed must be determined, and the proper number of each type procured. These problems are quite different from other production problems, however, in that they directly concern human beings. A bar of steel is impervious to the manner, tone of voice, or language, of the person receiving it; a person is not. A steel bar doesn't care if its identical neighbor commands a higher price; an employee does. Steel bars may remain unused for weeks, be improperly blamed for defective work, or be thrown on the scrap heap—all without arousing their resentment.

Because employees have feelings, impulses, and independent thoughts, they react to the manner in which they are treated from the moment of their first contacts with the company. Their reactions and responses must be considered throughout their entire employment. A man cannot be described by a number, for he is different from all other men, and his individual affairs are all-important to him. Moreover, dealing as it does with human *values*, personnel management must stress the *art* of dealing with people. It is not a matter of books and theories so much as one of common sense and human kindness. Consequently, any sound structure of industrial relations must rest upon "fair wages and fair dealing," a phrase that means to the worker a decent living and an opportunity for a satisfying life.

To be completely successful, industrial relations require the unstinted support of the chief executive. Many companies well-known in this field reflect the influence of a dominating personality at the top of the executive pyramid. Morris E. Leeds, of the Leeds and Northrup Company, and George Eastman, George Westinghouse, and William C. Procter, of the firms that bear their respective names, have been outstanding examples.

Organization. The labor philosophy and policies of such executives are customarily made effective through a functionalized department of the organization in which control over such policies is placed in the hands of a specialist. In large companies, the segregation of industrial relations from the operating activities is almost universal. Whether or not the control of personnel activities should be centralized or decentralized is a problem, however, on which opinions differ. On the one hand, in such companies as A. T. & T., DuPont, General Electric, and Westinghouse, in which the physical distances between branches are great, decentralization has seemed wise. On the other hand, a high degree of centralized control is to be found in such companies as American Rolling Mill, Procter and Gamble, and Standard Oil of New Jersey.

The policy followed by many personnel managers is both to advise the operating executives and to facilitate their work, but to do nothing that will weaken in any way the relationship between the line executives and their subordinates. The direct control of the worker is therefore vested in his foreman and in other line executives. This means that the personnel officer works *through* the foremen and other department heads and not *around* them. A sound policy dictates that the personnel manager advise and train the line executives in accordance with best practice and permit them to interpret company policies in dealing with their subordinates. In short, he leaves the giving of orders to the line executives but furnishes them with staff advice from a centralized source. He does not permit relationships about which the foremen know nothing to grow up between the personnel department and the workers. This does not include those confidential problems so frequently brought to the personnel department. These, of course, must be scrupulously safeguarded. Rather, it refers to the tendency on the part of workers to play the personnel department against their superior officers, and on the part of some personnel managers to satisfy their own desire for power by dealing directly with workmen when the foremen and department heads should be consulted.

The ramified activities undertaken to maintain employee morale and efficiency may be illustrated by the Sperry Gyroscope Company, Inc. Here, the industrial relations work is organized into three major departments reporting to the top industrial relations executive. These departments are Manpower, Employee Relations, and Employee Services. The first is responsible for selection, employment, training, placement, and termination of all employees. The second is responsible for job evaluation, salary and wage administration, and all labor and union relations. The third is responsible for feeding, medical service, recreational activities, administration of insurance and pension plans, credit union, employee information service, and personnel counseling.

Each of the major activities in a well-rounded industrial relations program warrants separate consideration.

Employment. The employment activities of an industrial relations department include the development of adequate sources of labor supply and intelligent selection from among the applicants. The sources to which firms ordinarily turn are the friends of employees and applicants at the employment office. In addition, they have recourse to other sources—for example, colleges and employment agencies—for securing people with certain specialized types of training and ability. If all of these sources fail, then blind advertisements may be placed in newspapers and trade periodicals. Even when unemployment is heavy, companies find a dearth of trained mechanics, such as those who can handle certain types of heavy equipment and who can do certain kinds of welding.

The actual selection of employees is done by interviewers in an employment office. The procedure ordinarily starts when the head of a department sends a requisition for a worker to the employment office. A company should attempt to transfer to the job someone already employed in the firm in order to give existing employees the benefit of promotion whenever possible. If no suitable person can be found within the organization, outsiders are then considered. The process of selection centers around the interview, a proceeding in which the interviewer must be exceedingly skilled if the best results are to be obtained. Blunt, direct questions are unsatisfactory. Instead, the interviewer should make the applicant feel as much at home as is possible in view of the tenseness with which most applicants face such a crisis. As the applicant is led to tell his story in his own way, the interviewer draws his conclusions concerning the former's suitability. No uniform opinion exists concerning the efficacy of tests as an aid to selection. However, many companies use trade or aptitude tests; others use various types of mental alertness and psychological tests. The use of tests will doubtless increase as the tests are themselves tested to determine their value and limitations.

An employment manager whose first duty to the company is to secure the best workers that can be found for the salaries paid must decide upon and follow a policy with respect to his relations with department heads. If the department heads are permitted or encouraged to send specific individuals to the employment office with the request that they be hired for particular jobs, the employment manager will find himself in the position of merely approving employees that the department heads have picked out. A sounder policy is one in which the employment office insists upon the initial selection of candidates for each job, and thus serves as a sieve in the process of up-grading the force. However, if the employment manager is wise, he will submit to each department head two or three applicants, all of whom meet the general standards of the company. The department head can then select the particular person who seems to him to meet the requirements best or who catches his fancy.

The freedom with which an employment department can cultivate sources of supply or choose among applicants may be greatly restricted by seniority provisions of union contracts. Such contracts usually provide that laid-off employees should be recalled before new employees are hired, and further that such recalls shall be made in the order of seniority. The extent to which seniority provisions are modified by ability requirements is pertinent to the effectiveness of selection.

One of the chief employment problems met in administering seniority provisions is that of filling requisitions promptly. Usually, the employee with the greatest seniority has first claim on an opening and is given a specified period, say five days after recall, in which to apply. If successive employees on the recall list fail to respond, the job may remain unfilled for weeks.

The "closed shop" clause in union contracts is even more restrictive. Under such provisions, the company can hire only union men. In most instances this will be effectuated through union hiring halls. Free choice of applicants is limited to those jobs not covered by the union agreement and to openings for which the union is unable to furnish men.

Training. After people have been selected they must be trained. In some respects a company has personnel problems of the "buy or make" type. It may seek to fill its requirements, for example, for machinists by hiring fully qualified applicants, or it may undertake to train them. It may find its purchasing agent outside the concern, or it may "promote from within." In either event, training of some sort will be necessary.

A complete training program may include induction training, "vestibule" schools, apprentice courses, on-the-job training, foremen's conferences, technical or executive trainee courses, and broad educational instruction.

By induction training is meant the adjustment of the employee to his new job so that he can carry on under the supervision normally available. Induction programs attempt to acquaint the worker with the company's history, products, and policies, as well as with information concerning working conditions, such as hours, time-card system, and shop rules and regulations. In certain types of firms, such as department stores, the selection and placement of people can scarcely be considered complete unless induction training is included, often with "vestibule" training.

The knowledge and skill required for some jobs, such as welding, may be taught trainees in a "school," before the employee is actually assigned to a production job. In such training, the production operations are approximated as nearly as possible, and the trainees may even receive their instruction on actual parts or products made by the company.

Other occupations require a long period of study and practice before an employee acquires the requisite skill. In training employees for these "crafts," a company must provide a combination of formal classroom instruction in related subjects, such as mathematics or mechanical drawing, and varied work experience. In most states, apprenticeship standards are established by law.

By far the most common form of training is that given "on-the-job." It may be provided by other employees, by special instructors, or by supervisors. Frequently less skilled workmen are assigned to first-class craftsmen for instruction. Set-up men may train "green-horns" as part of their regular duties. During periods of rapid expansion, when the ratio of new workers to experienced ones is high, the volume of training may warrant the conversion of skilled operators into full-time instructors. Moreover, the training of employees under his supervision is a continuing responsibility of each foreman.

Training is required whenever there is a change in process or method; to prepare employees for up-grading; and to improve safety, quality, and output.

Most companies recognize the need for the training of supervisors and technical personnel. A common program for training the former is through foremen's conferences.

A different sort of job training has been emphasized at Westinghouse. The highly technical problems involved in producing electric locomotives and similar apparatus necessitate the hiring of employees who can understand them. Those trained who do not remain in the employ of the company are likely to get jobs with electric operating companies or other customers, where their training will prove mutually beneficial; thus the cost of their training is not lost entirely. Consequently, Westinghouse has a comprehensive program that ranges from pure job instruction to postgraduate university courses.

In the training problems of American Rolling Mill, the assignments are written at headquarters and the rest of the responsibility is placed squarely upon the shoulders of each works manager, who selects the instructors from among his executive assistants. The instruction centers upon specific jobs—their cost, their effect upon the quality of product, and so forth. Eastman Kodak goes one step further: not only are the assignments prepared at headquarters, but the executive in charge of foreman-training helps to train the executives who later lead the discussions among the foremen. In short, the master group serves as a proving ground for tests, questions, and problems prior to their presentation to the foremen. This preliminary discussion results in a uniformity of policy and treatment.

Wage administration. Whatever else might be included in an industrial relations program is superfluous if sound wage administration is not stressed. The "pocketbook nerve" is indeed one of the most sensitive in employee relations. Wage administration, discussed elsewhere in this text, is the very heart of a personnel program.

Employee communication. The development and maintenance of good employee relations also requires two-way channels of communication: from the employees up through the supervisory levels, and from top management down. To assure employees that their complaints will be heard sympathetically requires a formal grievance procedure, even in companies whose employees are nonunionized. A device for ascertaining general employee reactions that may not take the form of grievances is the attitude survey. In addition, a well-designed suggestion system induces employees to offer ideas for improvement.

But employees desire more than a means of self-expression. A sense of "belonging" is cultivated by information as to the company's products, operations, people, and prospects. The attempt to provide such information may take the form of employee handbooks, newspapers, or magazines, letters from the president, bulletin board announcements, annual reports, open-house occasions, and other special employee meetings.

Job security. It is difficult if not impossible for an employer to build high morale among his employees if they work in an atmosphere of uncertainty. Hence, a problem on which general management must lend its aid to those charged with the direct responsibility for relations with workers is *the regularization of production and employment.* This problem has been much discussed, but with disappointing results. It is obvious to any observer of our economic affairs that industry by and large has been wholly unsuccessful in providing steady employment. This is especially true with regard to unemployment caused by cyclical fluctuations. But to the extent that unemployment is the result of seasonal irregularities in sales volume, a number of companies have remarkable records for securing stable production and regular employment. Among these are the California and Hawaiian Sugar Refining Corporation, Procter and Gamble, and Eastman Kodak.

Although the accomplishments of these outstanding companies are not likely to be copied universally, or even generally, they offer a challenge to firms less well managed. Their methods of attack have been quite similar. Their products consist chiefly of consumer goods for which demand is reasonably steady. It is also significant that certain of these firms have achieved control over the marketing of their products. In fact, both Procter and Gamble and Eastman have taken over the jobbing of much of their output in order to increase their information concerning the rate of retail sale and their control over the amount of finished stock not yet sold. In all of these companies, the building of adequate storage facilities was a prerequisite. Once these essential steps were taken, the leveling of the rate of production became a product of imagination and of careful planning.

Unfortunately it is impracticable to expect industry generally to succeed in regularizing production and employment in the same degree as these employers. Several substitutes have been developed, among which are plans for guaranteeing annual wages or employment, for paying severance allowances, or for providing supplementary unemployment benefits.

Several companies have developed plans for regularizing employee earnings even though production cannot be regularized. Such plans guarantee that employees will be paid for a specified number of hours of work a year, which amount is then distributed evenly throughout the year. The essence of all such plans is that employees receive advances for pay periods in which their earnings are below the guaranteed amount, and contribute to a reserve in those periods when actual earnings exceed the guarantee. Perhaps the best known plans of this type are those of Nunn-Bush and Hormel.

Severance allowances cushion the shock of lay-offs. The United States Steel Corporation, for example, has agreed to pay its employees substantial allowances for unemployment resulting from the discontinuance of a department or plant.

State unemployment benefits also provide the basis for stabilizing employee income. To assure that the weekly income of employees will not fall below the level of state unemployment benefits, unions have demanded that employees be guaranteed a minimum amount of work in any week in which they work at all. Other companies supplement the state unemployment compensation.

Other financial provisions for security. Another factor to be considered is protection against the hazards of life by means of insurance. The hazards ordinarily provided for are illness, accident, and death. While state legislation has forced manufacturers to provide compensation for losses to employees from accidents incurred while they are at work, nonoccupational disability is not so covered. Consequently, leading companies have provided protection for this hazard through group insurance. A well-developed plan of this type will provide weekly benefits for time lost through illness or nonoccupational accidents, compensation for permanent disability, and life insurance. While most companies make group hospitalization or medical protection available through payroll deductions, some insurance plans also include surgical, medical, and hospital benefits. Until recently most insurance plans were developed and installed unilaterally by companies. Frequently the costs were borne in whole or in part by the employees, and participation was voluntary. After insurance plans were held to be within the scope of collective bargaining, benefits tended to be expanded and the costs to be borne by the company alone.

An allied topic is the provision of pensions or annuities to prevent employees from outliving their incomes. In a competitive society, a firm must confine its pensions to those who have spent a goodly portion of their lives in its service. Even with such a limitation, the cost is heavy. Yet if a management wishes to care adequately for its employees as they reach the age when they should retire, it must provide in advance for their necessary financial protection according to some such arrangement as that of the Scott Paper Company (see Figure 52).

The California and Hawaiian Sugar Refining Corporation adopted a contributory plan, under which the company buys for each employee who joins the plan a retirement annuity for each year of service rendered. These employees may purchase additional annuities. The older employees contribute an increased percentage of their salary toward their retirement protection. If employment is terminated for any reason before the normal retirement age, the employee has the option of taking in cash all that he has contributed plus interest, or of selecting an alternative arrangement.

Like insurance plans, pensions have entered the realm of collective bargaining. The winning of liberal pensions by the United Mine Workers spearheaded a broad movement for adoption of pension plans, or for increased benefits, the cost of which was to be borne directly by the employer and indirectly by the consumer.

Other provisions for financial security include plans to encourage employees to save, and facilities for borrowing to meet emergencies. The provision of facilities to assist employees with their savings involves both long- and short-run investment. The former obviously lends itself to using such devices as building and loan associations, but these are fraught with so much danger that they will not be discussed here. Many companies feel, however, that it is essential to provide some sort of "rainy-day" fund, upon which employees can rely in emergencies. Such savings plans for short-run investment usually consist of an arrangement with a savings bank to facilitate the making of periodic deposits through pay-roll deduction, or of a similar investment in government bonds, or of the establishment of a credit union.

A credit union is designed to serve the dual purpose of providing facilities for accumulating savings so that they will have a high degree of availability, and serving as a source for borrowing at reasonable rates. It has to do, therefore, with both thrift and credit, both of which are equally important. For this reason, membership should be limited to groups of people that have a common interest, such as employment by the same concern. In fact, "most States require that credit unions be formed within groups that have some common interest, either economic or social. . . . It may be a neighborhood. It may be common occupation, employment by the same establishment or membership in the same church, club, lodge, labor union or other organization."[1] In the organization of a credit union, the credit committee and the treasurer occupy critical positions. The former, which usually consists of three members, passes on loans, determines the security for each, and fixes the terms of repayment. The treasurer, whose official duties are more important than those of the president, vice-president, or secretary, manages the credit union in addition to keeping the books.

The condition best suited for the use of credit unions in industrial establishments is where labor turnover is low and where the number of persons employed in each producing unit is sufficiently small for them to be well acquainted with each other. Such a situation is to be found, for example, among postal, telephone, and railroad employees.

In contrast to the success of credit unions is the failure of stock purchase, a matter on which both employees and employers have suffered disillusionment. The general sentiment seems to be that it is unwise to sell common stock to rank-and-file employees. In spite of the loss of money and morale, however, some executives still believe in the principle if it is hedged around with enough protective features. These executives would either limit the purchase to a selected group, guarantee the payments until the expiration of the plan, or limit the offerings to preferred stock or to selected years. One senses that managements which did not embark on a plan of employee stock purchase when such things were in their heyday,

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[1] Arthur H. Ham and Leonard G. Robinson, *A Credit Union Primer*, New York: Russell Sage Foundation, 1930.

are now devoutly thankful in view of the abandonment of many such plans at heavy financial sacrifice to both the company and participants.

Employee stock ownership is too dangerous except for the most restricted use. It is both ill-advised for the employees, and questionable for the management for the following reasons:

1. It is poor advice to ask any workman to invest his savings in the same company from which he draws his pay check. If that company meets financial adversity, he loses not only his source of current income, but the savings on which he should be able to rely in emergencies.
2. It is poor financial advice to suggest to a workman, let alone urge him, to invest in the common stock of any one company unless he has first accumulated a "rainy-day" fund, the principal of which can be realized at any time.

The problem of employee savings and investment involves some risk to the employer because of the obligations, implied or otherwise, entailed by the mere installation of a plan. This responsibility can scarcely be evaded by the statement that the company is not responsible for the security of the principal.

Proper working conditions. An up-to-date personnel program must provide satisfactory working conditions, such as sanitation, ventilation, illumination, and proper safeguards. The approach of the Bell Telephone Company of Pennsylvania to the problem of reducing accidents is significant because the executives spent some time in deciding upon the procedure. Although full recognition was given to the value of mechanical safeguards and of making department heads responsible for the maintenance of safe conditions, the principal emphasis was placed upon publicity. The theme of safety was made realistic to the employees through the "first aid" then being featured, and use was made of the competitive spirit by fostering divisional contests under Red Cross auspices.

The first step was the organization of divisional safety committees, of which the superintendent was an active and per-

Conditions for benefits:	Attainment of age 65, but any member may retire after 55 provided he has completed twenty years of continuous service.
Participation:	When an employee completes five years of service he becomes a member automatically.
Contributions:	Company pays entire cost of providing benefits based on earnings up to $5,000 a year. A member who desires to receive a retirement benefit based on earnings in excess of this amount must contribute each year 4 per cent of his earnings in excess of $5,000.
Base earnings:	Average of five highest annual earnings during the last ten years preceding retirement.
Benefits:	¾ per cent of base earnings up to $3,000, plus 1¼ per cent of base earnings from $3,000 to $5,000, plus 1½ per cent of base earnings in excess of $5,000 (for contributing members) multiplied by the number of years of continuous service after January 1, 1945. In addition, members with service prior to 1945 will receive ¾ of 1 per cent of earnings at the 1944 rate multiplied by years (not exceeding fifteen) of continuous service before January 1, 1945.
Administration:	The plan is administered by a Retirement Board of not less than three persons appointed by the Board of Directors. Payments by the company and by contributing members are deposited with a trustee who, under an Agreement of Trust, holds and invests the funds, subject to disbursement only for use in accordance with the rules of the plan.

Figure 52. Scott Paper Company Retirement Plan.

manent member. Each committee comprised three members of the supervisory force, in addition to a representative of each vocation. It fostered safety education by using signs prolifically. The second step was the provision for periodic inspection of the plant in order that management might be kept advised of hazardous conditions and promptly correct them. The development of a definite inspection routine resulted in the elimination of some 20,000 dangerous situations in about six years. This step led logically to the third measure, namely, the provision of mechanical safeguards.

The American Rolling Mill management, on the other hand, has come to feel that the appeal to men's emotions and the setting up of elaborate rules of safety are productive of temporary results only. After pursuing a plan of organized accident prevention for some seventeen years, it concluded that the soundest approach was to develop a high degree of job technique. Consequently, safety and training were merged on the theory that only when workers know how to perform each operation properly will accidents be kept permanently at a minimum.

In any group of firms outstanding in their attention to personnel, the improvement of employee health is likely to be featured. As one travels from R. H. Macy & Company, Inc., with its extremely well-planned facilities for preventive medicine, to the Schenectady plant of General Electric, to the Kohler Company, and to American Rolling Mill, he finds medical departments to which much attention and expense have been devoted. In fact, all of these companies, as well as many others, have such elaborate hospitals with technically efficient staffs of doctors, nurses, and dentists that it is scarcely fair to single out any one as a model. Companies having adequate facilities for medical care spend $10.00 or more per capita a year on this work. Few companies, however, keep as careful records of sickness as they do of accidents. This seems a curious fact considering that, in terms of days lost, a public utility has found sickness to be seventy-five times as important as accidents, and a steel company has found it to be six times as important.

Labor Relations

Since the passage of the initial National Labor Relations Act in 1935, it has been the avowed policy of the United States to foster and encourage collective bargaining. Inasmuch as unions have become the bargaining agents for so many employees with respect to wages, hours, and conditions of employment, managerial decisions bearing on these matters are conditioned to a large degree by union policies, attitudes, and agreements.

Wage provisions. The core of every collective agreement is the wage section. Whenever a union represents employees, the determination of wage levels, occupational rates, and wage policies become a matter of negotiation rather than of unilateral decision by management. Wage policies of unions differ. Some oppose incentive plans in principle, others accept them. Some welcome job evaluation, others prefer the setting of individual job rates by negotiation. Some unions prefer single rates for jobs; others prefer rate ranges.

The degree of union participation in time study, job evaluation, and merit rating has been the subject of much discussion. In some companies, union time-study men check task times, but more frequently, company analysts establish the standard times or the piece rates, subject to challenge by the union and subsequent review in the grievance procedure. Regardless of whether the union actually participates in making time studies, the collective bargaining agreement will normally set forth "the rules of the game" if an incentive plan is in effect. Typical of the matters covered by contract provisions are the establishment of new rates, conditions for changing rates and criteria for measuring their adequacy, payment for unavoidable delays, and time intervals for computing incentive earnings.

Where occupational rates are established by job evaluation, unions have participated in the development of the plan to be used, in the approval of descriptions, in the evaluation of jobs, and in the determination of the wage curves. Where such plans have been adopted, the wage agreements spell out in some detail the manner of dealing with "incumbents" whose rates are in excess of those established for their jobs in the wage schedule.

In developing wage plans, many managers favor rate ranges that enable the better workers to earn differentials over their less able fellows who occupy the same jobs. When unions are a party to a wage agreement, they have the legal right to participate in the review of an employee's performance. In such cases, some managers feel that there is a tendency for increases to become automatic rather than to be based on merit. In other companies, the union has succeeded in substituting single rates for rate ranges—usually at the top of the previous ranges. The union position is simply that "merit" increases, to which they are not a party, allow for favoritism and that, as the sole bargaining agents on wages, they have a right to participate in the review and decision resulting in such increases. This position has been upheld by the courts.

Of great concern to many companies is the fact that large unions, nationwide in scope, have adopted the approach of a nationwide or industrywide pattern in negotiating wage increases. This approach seeks to establish either a uniform wage rate for an occupation, or a uniform wage increase for all employees. A uniform wage rate ignores local factors that influence wage levels; a uniform wage increase reduces the percentage of differential between low and high skills. When a union is large and powerful, the individual company, particularly if it is small, may find itself unable to bargain a separate wage agreement; instead, it may have a settlement imposed upon it similar to the one reached by the union with a large corporation, such as United States Steel.

Seniority. The urge for job security has resulted in provisions that set forth the operation of seniority in promotions, demotions, lay-offs, and rehiring. Engendered by a fear of supervisory favoritism or of discrimination because of union activity, such provisions limit managerial discretion. Few managers would contest that length of service should govern in the situations enumerated above, provided other factors, like ability, are equal.

Many employers argue that, for maximum efficiency, employees should be upgraded, retained at the time of layoffs, and rehired on the basis of ability. At the opposite extreme is strict seniority where length of service is the determining factor. Midway between is the provision that seniority shall govern providing the employee is able to do the work in a *satisfactory* manner.

In addition to its application in lay-offs, promotions, and rehiring, seniority may govern transfers and special privileges. For example, choice of shift, of job, or of vacation period, may depend upon length of service. Since the company's authority to act is limited by seniority provisions, they should be carefully appraised by management before adoption. From the union point of view, a widening of the application of seniority provisions increases job security; from the company's point of view such increased security may reduce the initiative or incentive of its employees. Both unions and employers must strike an appropriate balance between recognition of length of service and encouragement of individual initiative and advancement.

"Fringe" benefits. Although such items as vacations with pay, insurance benefits, pension plans, paid holidays, payment for travel time, and sick leave have been called fringe issues, individually and collectively they represent substantial additions to the annual outlay for personnel. Because these items are usually reflected in overhead rather than direct labor costs, figures for average hourly rates, weekly pay rolls, or labor costs per unit may be entirely misleading. Only if these fringe benefits are converted into cents per hour or percentages of pay roll, can their significance be realized. All fringe benefits have become increasingly important in labor negotiations.

Grievance machinery. The day-to-day administration of the collective agreement rests upon the grievance procedure. At the initial step the individual employee should attempt to settle his grievance with his immediate supervisor. Provision is then customarily made for appeals through successive management levels, and finally for arbitration.

There are conflicting views as to the type of arbitration that should be provided. Disputes may be submitted to an arbitration panel, or to a single arbitrator. The arbitrators may serve for the duration of an agreement, or may be designated for each separate case. An arbitration panel usually consists of three arbitrators, one selected by the union, one by the company, and the third jointly. Those advocating the use of a panel contend that both parties are given an opportunity to review the evidence with the impartial chairman, permitting them to correct misunderstandings or misinformation upon which he might otherwise base a decision. Those favoring a single arbitrator contend that the impartial arbitrator decides the case in any event, and that he can do so with more dispatch if working alone. Those advocating the use of the same arbitrator for a fixed period or for the life of an agreement argue the advantage of the familiarity with the agreement, occupations, and operations that he acquires. Those advocating the designation of an arbitrator for each case desire freedom to change if they do not like an arbitrator's methods, reasoning, or decisions.

Management rights. Collective bargaining removes many matters from the area of unilateral decision by management. As collective bargaining has progressed, the area subject to collective bargaining has increased and the area of managerial freedom has decreased. Consequently most collective agreements contain management clauses, of which there are two general types. One enumerates in detail the rights retained by management. This type is based on the premise that unions encroach on any management function not specifically reserved to the company. The other management clause is general in nature and reserves to management the jurisdiction over all matters not specifically covered by the agreement. Its advocates contend that the detailing of management rights may, of itself, be construed as yielding any rights not mentioned.

Employee participation in management. Many union objectives, policies, and practices are at cross-purposes with those of management, e.g., restrictions of output, retarding the introduction of labor-saving machinery, and overemphasis upon straight seniority. Some unions go beyond such limitations, however, and demand participation in the decisions of management, even those pertaining to the pricing and marketing of the product.

Many union leaders, however, do not wish to assume the responsibility for such matters as time study, job evaluation, determination of number of workers needed, and discharge. They prefer to "police" the results of company action, or to negotiate additional restrictions. When the union has participated in an unpopular action, the union leaders are embarrassed and their positions endangered. However, it appears that both union participation in management, and union restriction of management's freedom of action will continue to grow.

Questions:

1. In training supervisors, would you favor having discussion groups conducted by company executives or by outside instructors?
2. Apprentice courses require a number of years. How would you determine the number to indenture?
3. Distinguish between employee relations and union relations.
4. What are the advantages and disadvantages of an early age of retirement?
5. Debate whether ideas should be communicated to employees directly or through the union.
6. Should employee recreation, pension funds, and credit unions be under the control of labor exclusively, of management exclusively, or under joint-control?

Section XI

ORGANIZATION

CHAPTER 27

Organization Structure

ORGANIZATION, dealing as it does with human relationships, is at once the most intriguing and the most difficult of all phases of management. In spite of the difficulty of comprehending its nature, organization must be recognized as the most important of all the means of direction and control that the chief executive of a business has at his command. The organization is the nervous system of a company.

Whenever two or more persons combine their efforts in a definite way for a given purpose, there is an organization. To be more specific, an organization structure consists of relationships not only between one person and another, as between a superintendent and a foreman, but between people and the work to which they are assigned. Some of these relationships can be portrayed graphically by organization charts; others are intangible. The latter, which are the more important, can be understood and appreciated only by "insiders." Relationships are therefore the basic element used in the design of organization structures.

Whenever a great many workers are employed, the relationships among them are numerous and involved. Consequently, some relatively fixed arrangement of these relationships is essential. Such an arrangement may be termed the "organization structure." Just what form of structure will prove best for any given firm depends upon its objectives, the caliber of men available, and the particular conditions under which they work. Even the determination of how an organization may best be subdivided depends upon its own peculiar aims and conditions. Structure is not an end in itself, but it can increase or decrease the effectiveness of those who operate under it.

Since the definition of an organization mentions both people and work, the analysis might be approached from either angle. For the purpose of this text as well as for that of making actual reorganizations, it is more logical to analyze the work to be done before considering the types of individuals to whom it is to be assigned.

Division of labor. If the problem of how best to accomplish the total amount of work that a company needs to have done is considered, the classic concept of the subdivision of labor is immediately encountered. The division of work into separate duties is found in all types of organization and is centuries old. The extent to which subdivision of labor has been carried in large companies, such as the Bell System, General Motors, and General Electric, with hundreds of thousands of employees is, of course, very great. For instance, on the killing floor of a meat-packing establishment, there are about forty operations, all different.

In developing or rearranging an organization of people to accomplish certain work, it is important to consider the extent to which the work should be subdivided. If the jobs are limited in scope, certain advantages from specialization are obtained. These advantages may, however, be offset by the disadvantages of lack of flexibility, and of the restriction of individual initiative. The jobs should be neither too large nor too small to be filled by the men and the women whom the company has available or can secure. Jobs requiring supermen are difficult to fill. A "star" salesman, who covers a large and important territory, or a superintendent who has been saddled with countless duties, are traditionally difficult to replace. Since the majority of men available for hiring are of "average" ability, jobs should be constructed accordingly.

In most industrial concerns, an analysis of the work done would yield the following classification:

1. Direct operating activities (making and selling).
2. Financial functions (the receipt and disbursement of money).
3. Facilitating activities that assist direct operations.
4. Control functions, such as inspection.

The direct operating activities might be described as a continuous sequence of steps, the relationship of which is shown by Figure 53, which, with Figure 54, was adapted from charts used by Mr. A. B. Gates for executive training at the Eastman Kodak Company. These activities start with the vendor of the incoming materials and end with the customer who receives the product. The cycle is completed when the company bills the customer and in due time receives payment—unless it is unlucky enough to secure only a bad debt (see Figure 53).

After the analysis of work into activities, each activity may be further subdivided into jobs. A job usually consists of one or more of the types of duties outlined below. The extent, however, to which these types are combined in one job depends upon the rank of the person holding the job (that is, his level of authority).

1. Performance of manual or mental work (the actual doing).
2. Immediate supervision required to get the work done.
3. Planning of what is to be done, and how, when, and where the work will be performed.
4. General direction of the work to see that it is in line with the company objectives and policies, and that it is coordinated with work done elsewhere in the concern.

So far we have merely analyzed the make-up of the work, or jobs, performed at various levels of authority in the "executive pyramid." In an attempt either to develop a new organization or to rebuild an existing one, it is essential to think first of the jobs to be done, and then of the individuals who are to fill them. Proper balance can be secured only when the work to be done is considered apart from the human element. In building an organization, one might think of the duties that constitute a job as the base of the structure, and the different ranks as constituting the layers of supervision. The application of this idea is graphically illustrated in Figure 54.

Delegation of responsibility and authority. Any given job has two aspects: the responsibility involved and the authority inherent in it. Responsibility has to do with the duties

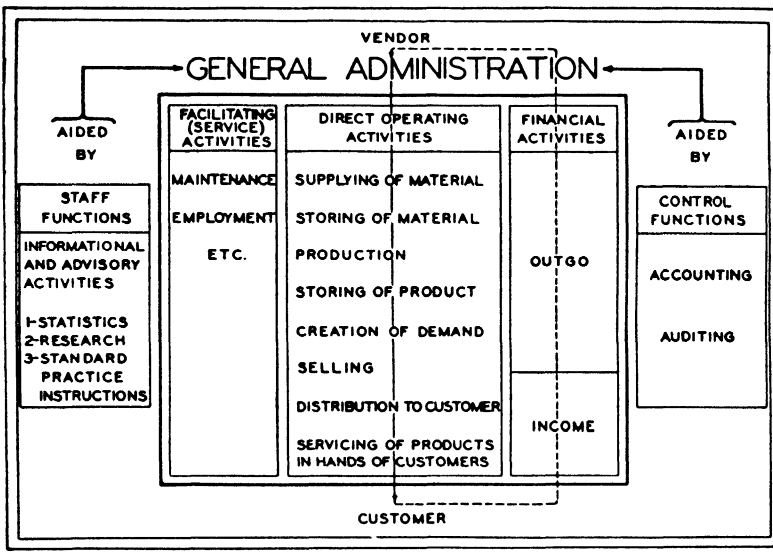

Figure 53.

assigned to an individual and with his accountability for their satisfactory discharge. Some responsibility is involved on every job, whether it is that of the clerk or of the sales manager. Often, however, the responsibility is limited because it is shared with a superior. An example of such limitation is a foreman working under the close guidance of the shop superintendent.

It is always assumed that if a person is given a certain responsibility, he should have the authority necessary to discharge it. Authority connotes the power to exercise control and to require action. In business, the highest authority is vested in the president or the general manager. The president often coordinates the executive plans, and the general manager serves as the top line-official in the execution of these plans. In the Catholic Church, authority centers in the Pope; in the United States Government, in the President; in an army, in the commander-in-chief. This authority must be passed down through the entire organization structure by the

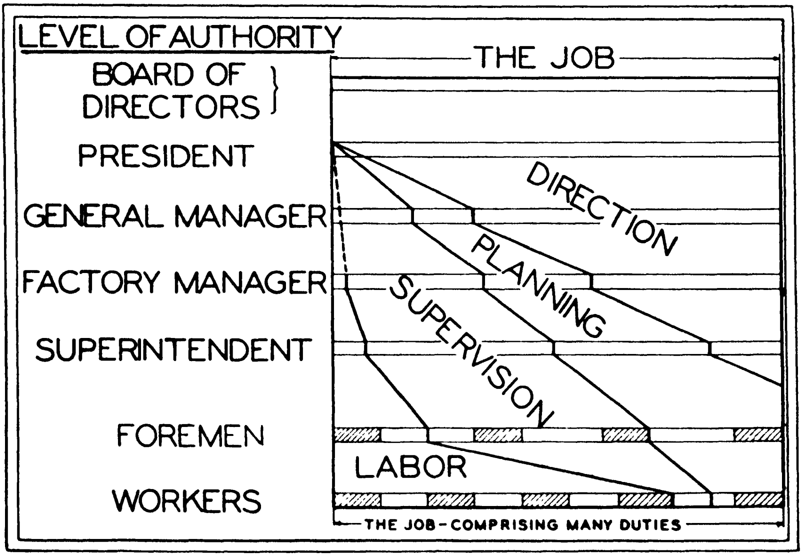

Figure 54.

delegation of authority to successive ranks of line executives, all of whom, taken together, form the executive pyramid. At its apex is the top line executive mentioned above. Below him are a series of executives represented by steps graduated according to the degree of authority and responsibility. This pyramid exists in both small and large organizations, whether in industrial, military, or church affairs. In the army the series of steps is extremely long, whereas in the Catholic Church it is rather short. In general, the larger the organization, the more steps there will be.

Delegation of authority means the conferring by one of higher rank of a specialized part of his authority. The one to whom the authority is delegated becomes responsible to the superior for doing the job, but the superior remains responsible for getting the job done. Such delegation becomes necessary whenever the purpose or objective requires the effort of more than one person. The housewife delegates to her maid; the boss of a road gang, to his pick-and-shovel men; the factory manager, to his superintendent; and the sales manager, to his district managers. The term means merely the conferring of authority of some kind, even including the right to delegate in turn.

An executive who is a real leader finds it easy to delegate authority to others, but does not make the error of believing that when he delegates authority, he relieves himself of responsibility and its obligations. Such a leader delegates certain of his duties as soon as the total job which he is carrying taxes his own ability and time.[1]

The actual amount of authority delegated to subordinates varies both with the size of the area under the jurisdiction of these persons and with the degree of control permitted over that area. In one plant, the inspection in all departments may be placed under one man; in a second, there may be several independent inspection departments. Or inspectors may or may not have authority to instruct workmen or to order them to stop their machines. Authority is distinct from leadership. Leadership is essential if the organization is to be effective, for it alone can provide the spark to give life to the organization; but it requires an organization through which to function.

Span of control. The effectiveness of an executive's supervision is related to his span of control. The span of control may be defined as the number of subordinates reporting to one superior. At the upper levels of authority, the activities are

[1] J. D. Mooney and A. C. Reiley, *Onward Industry*, page 86. New York: Harper and Brothers, 1931.

so numerous and complex that the ratio should not exceed four to one, or five to one. At the lower levels of supervision, when the work is more homogeneous and the problems less perplexing, the ratio may be much larger, say ten to one, or even fifty to one in the case of the supervision of common laborers.

A mathematical explanation of this need to restrict the number of organizational relationships has been advanced by V. A. Graicunas, Parisian consultant. It rests on the thesis that the "span of attention" is limited so that the ordinary individual cannot memorize and repeat, when read to him, groups of figures of more than six digits. He then develops the theory that an increase of one subordinate adds not merely one direct relationship to those of the superior but it adds group and cross relationships as well. The subordinate will have relationships with each possible group of fellow subordinates who report to the same boss, and cross relationships with each fellow subordinate as an individual. Whereas the number of direct relationships increases in direct proportion to the number of subordinates, the other types increase more rapidly.

Practical experience confirms the fact that too great a span of control leads to ineffectual supervision. Not only is the superior unable to maintain mastery over all the details, but delays result because his subordinates are unable to consult with him promptly. The remedy is either to merge departments or to introduce one or more new levels of authority under the superior. For instance, a sales manager with ten district sales managers reporting to him directly may find a solution by creating two new positions, Eastern and Western sales managers, between whom the supervision of the ten districts is divided.

Bases for constructing departments. Departmentalizing may be considered as part either of the analytic process of subdividing activities or of the synthetic process of assembling jobs into groups. The important problem is to select the basis for departmentalizing best fitted to the circumstances and resulting in departments that can be effectively supervised and coordinated. The bases in common use are: area, or territory; product; process; and function (that is, the grouping of activities or duties similar in nature).

In practice, the departmentalizing often shifts from one basis to another, as in the Bell System and its twenty-four constituent operating companies.[2] In deciding on the most effective basis for a given concern, consideration should be given to grouping similar work in order to increase expertness, and to locating the department head close enough to the work in order for him to supervise it. A satisfactory balance should be established between proximity to the work and proximity to the next higher executive.

Departmentalizing on an area basis is typified by sales organizations having district sales managers who allot a specific territory to each salesman. In the factory, such departmentalization is illustrated by the placing of a separate superintendent over each of several scattered plants. In an organization in which a separate group of executives is responsible for making or selling a given line of product, the basis of departmentalization is product. In the General Electric and Westinghouse organizations this basis is used extensively. Process is an extremely common basis in shop organizations in which a foreman is usually assigned to a single step in the process, such as forging, assembling, or shipping.

[2] "The three principal limiting factors of departmentalizing are size, range of required abilities, and possibilities of intercommunication. Even in the simplest standardized tasks each man has his limit, imposed sometimes by muscular, sometimes by psychological factors, and more often by both. If a man is really to lead men—to influence those immediately under his direction—there will be some maximum numbers of them to whom he can give his fullest service. To spread himself out too thin over a large number is notoriously poor management practice; and to have too small a number unnecessarily restricts his field of influence. . . . The second factor in deciding what the work of a department, a worker, or an official is to be, is that the abilities required should be kept as nearly of a kind as possible, so that no unnecessarily wide range of knowledge, or variety of special adaptabilities will be demanded." Henry S. Dennison, *Organization Engineering*, pages 137-138. New York: McGraw-Hill Book Co., Inc., New York, 1931.

In modern organization, departmentalizing according to function has become so important that functionalization may be considered one of the chief organization principles, subordinate only to the major principle of coordination. Functionalization means the grouping of managerial activities according to kinds of duties. Examples of managerial activities are purchasing, employment, and inspection. The grouping of activities that merely represent steps in the manufacturing process, such as forging and assembly, are not instances of functionalization. For example, functional differences exist between a pitcher and an outfielder, an infantryman and a cavalryman, a minister and a deacon, a coach and a business manager, and a backfield coach and a line coach. In contrast, the distinction between coach and assistant coach, manager and assistant manager, colonel and major, and bishop and clergyman represents gradations in authority.

Functionalization may also be defined as a form of subdivision of labor that results when similar groups of activities, such as purchasing or inspection, are separated from the regular "line" activities and placed under specialized direction and control. Although it was not new, the idea of functionalization was popularized by Frederick W. Taylor as the solution to the problem of the overburdened foreman. Even though the most important applications have proved to be in the ranks of management above that of the foreman, Mr. Taylor's analysis of the foreman's job stresses the basic reason for functionalization. After studying the jobs of machine-shop foremen, Taylor decided that these men had at least nine separate duties to perform:

1. They must be good machinists.
2. They must be able to read drawings.
3. They must plan to have the right jigs and tools ready ahead of the job.
4. They must see that each machine is kept clean and in order.

5. They must check quality.
6. They must see that their men work steadily and fast.
7. They must see that the right job gets to each machine.
8. They must help in the fixing of rates and with the time-keeping.
9. They must discipline the men under them.

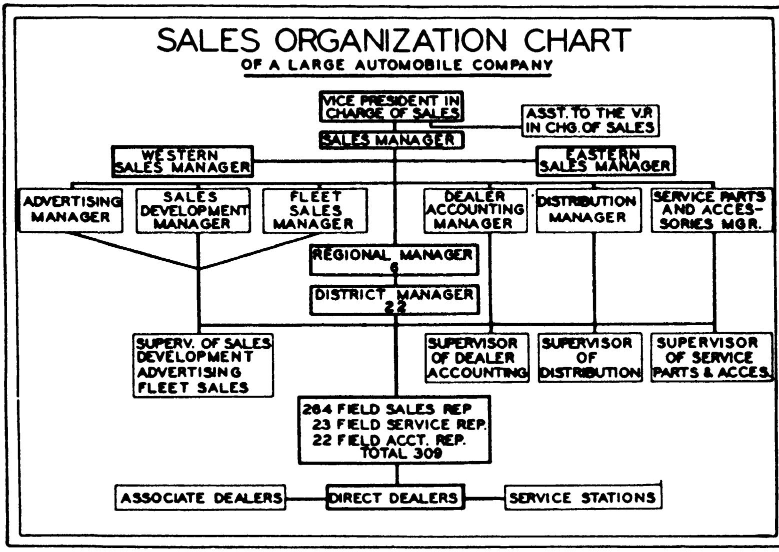

Figure 55.

Yet to meet the requirements of this job, one would need all, or most, of the following qualities: brains, education, technical knowledge, strength, dexterity, tact, energy, grit, honesty, common sense, and good health. Taylor believed that a man having three of these qualities could be hired for a laborer's wage, but that a man posessing five of them was hard to find, and that one with six or seven was almost impossible to discover. Because of the obvious difficulty of any ordinary mortal stretching himself over all of the duties enumerated, companies have split off activities such as purchasing, inspection, and employment, and turned them over to specialized departments. Sometimes these departments actually do the work; at other times, they merely control or advise as to method.

Disadvantages of functionalization. Students of management, such as John Lee, have pointed out that, although the functional system is inevitable just as is mass and machine production, its advent has disadvantages as well as advantages. A full-fledged functional system is hazardous in that it tends to undermine discipline and to rob the worker of the sense of creating a completed product. Moreover, it increases the possibilities of friction to such an extent that it offsets some of the advantages of specialized skill. Again, it is characterized by a lack of elasticity that often causes a functional executive to feel that he is unduly restricted. As the specialist looks around him at the activities that touch his own, he often feels that his specialized training is a deterrent to his full development. Those conscious of their ability thus come to feel that the functional system limits their scope, and are resentful.

Consequently, it is paradoxical that the best results from the functional method follow when it is adopted slowly, and is not substituted completely for the geographical basis of departmentalizing. Most organizations grow like Topsy, and unless functional control is properly woven into them, it is impossible to discover the happy balance between functional and general administration. The fact that military men have discovered the best balance for their own purposes accounts for their singular success. After adopting signals, communications, ordnance, airplanes, and tanks, they gave to each its full functional development and at the same time restricted each one to its proper niche in a balanced plan.

Types of organization relationships: line, staff, and functional control. Nearly every job involves a mixture of relationships, part of which are of the line variety, and part of which are of the staff variety. Line relationships emphasize discipline, the giving of orders, and other aspects of what is usually implied by the term "bossing." In contrast, staff relationships do not involve the authority to give orders as such, but rather counsel, information, and other facilitating service. In other words, line stresses the aspect of control; staff stresses that of facilitation. Falling between these two types are the functional relationships, often found in departments organized on a functional basis.

To elaborate further the distinction between line and staff relationships, the staff represents an auxiliary service to the line, that is, something that the line can lean upon for support. The staff has no authority to make decisions or initiate plans, but when plans are being formed, it may provide information or advice. It is supervisory only to the extent that it advises concerning the execution of plans already made, and for such purposes becomes vested with a special authority for some specific purpose. Because of its own function, it has no right of command, but occasionally it usurps such rights. This tendency for staff officials to usurp line authority is also evident in highly centralized companies in which even operating details are controlled from the main office. However, in any business, church, or army, there is no complete segregation of staff from line duties. So-called staff employees may advise with reference to both the making and the execution of plans, but the responsibility for approving and for carrying out the actual plans always remains with the line executives. Staff assistance, however, expands the powers of an executive in that it enables him to see clearly the relation of his own duties to all of the surrounding jobs and activities, and to get a coordinated picture of the functioning of the entire organization.

The third variety of organization relationship, functional control, is control over methods but not over execution. More specifically, it means that the holder of such a job would have the authority to see that proper methods, procedures, and policies were followed, but that he would have no authority either to assign work or to check up on the amount of work done. To illustrate, the comptroller of a plant having a number of branches may determine the accounting and budgeting methods to be followed, but the accountants, bookkeepers, and so forth in the several plants might report directly to the heads of those plants. They would follow the methods prescribed by the comptroller, but if any one of them wishes to "get a day off," he would ask his local boss.

Structural aspects of coordination. Coordination is often considered the most important principle of organization. It is essential for unified and effective action. The parts of an organization must be "meshed together," much as gears are meshed, if they are to do their work efficiently and without friction.

Much of the task of coordination belongs to the operating side of organization, which is discussed in the following chapter, but it also requires attention to structural design. The most effective means of providing for the coordination of varied activities is the establishment of key jobs, so located as to permit their incumbents to keep the activities from veering off in divergent directions or from clashing. To be effective the activities supervised should be placed in the departments so as to avoid either duplication or lack of attention.

Still another device is the use of conferences and committees. These have been found useful for the securing of information and opinion before actual decisions are made. However, if they are too large, or are saddled with the responsibility for converting decisions into action. they are notoriously weak. This limitation is doubtless responsible for the saying that the "best committee is a committee of one."

Maintenance of a balanced structure. Since one of the tests of a sound organization is balance, the causes of unbalance are worthy of attention.

One is the expansion of certain jobs or departments as the result of the desire for personal aggrandizement. Ambition sometimes leads executives to seek control over additional activities in order to build up their prestige, or perhaps to satisfy their egos. The result is a grouping of activities that

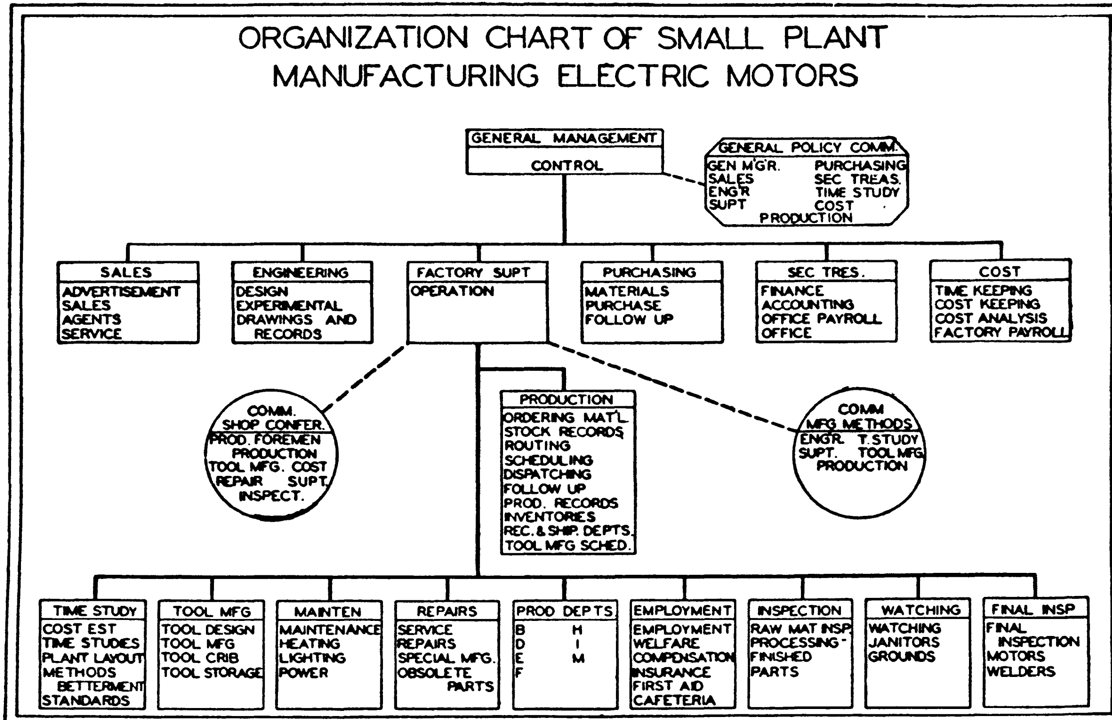
ORGANIZATION CHART OF SMALL PLANT
MANUFACTURING ELECTRIC MOTORS
GENERAL MANAGEMENT
CONTROL
GENERAL POLICY COMM.
GEN M'GR. PURCHASING
SALES SEC TREAS.
ENG'R TIME STUDY
SUPT COST
PRODUCTION
SALES
ADVERTISEMENT
SALES
AGENTS
SERVICE
ENGINEERING
DESIGN
EXPERIMENTAL
DRAWINGS AND RECORDS
FACTORY SUPT
OPERATION
PURCHASING
MATERIALS
PURCHASE
FOLLOW UP
SEC TRES.
FINANCE
ACCOUNTING
OFFICE PAYROLL
OFFICE
COST
TIME KEEPING
COST KEEPING
COST ANALYSIS
FACTORY PAYROLL
COMM.
SHOP CONFER.
PROD. FOREMEN
PRODUCTION
TOOL MFG. COST
REPAIR SUPT.
INSPECT.
PRODUCTION
ORDERING MAT'L
STOCK RECORDS
ROUTING
SCHEDULING
DISPATCHING
FOLLOW UP
PROD. RECORDS
INVENTORIES
REC. & SHIP. DEPTS.
TOOL MFG SCHED.
COMM
MFG METHODS
ENGR. T. STUDY
SUPT. TOOL MFG.
PRODUCTION
TIME STUDY
COST EST
TIME STUDIES
PLANT LAYOUT
METHODS
BETTERMENT
STANDARDS
TOOL MFG
TOOL DESIGN
TOOL MFG
TOOL CRIB
TOOL STORAGE
MAINTEN
MAINTENANCE
HEATING
LIGHTING
POWER
REPAIRS
SERVICE
REPAIRS
SPECIAL MFG.
OBSOLETE PARTS
PROD DEPTS
B H
D I
E M
F
EMPLOYMENT
EMPLOYMENT
WELFARE
COMPENSATION
INSURANCE
FIRST AID
CAFETERIA
INSPECTION
RAW MAT INSP
PROCESSING-
FINISHED
PARTS
WATCHING
WATCHING
JANITORS
GROUNDS
FINAL INSP
FINAL
INSPECTION
MOTORS
WELDERS

Figure 56.

lack homogeneity and has no basis in logic. Such executives may even duplicate work assigned properly to other departments; frequent examples are statistical analysis and record-keeping units.

A second cause is the assignment of activities to an existing department on the basis of expediency. It may seem easier to impose on some outstanding executive, even though he is already overburdened, than to take the time and trouble to make changes in the structure or in the incumbents of key positions. For instance, the chief engineer of a company, interested primarily in product research and methods study, gave scant attention to the maintenance that had been assigned to him. True, the mixture of research and maintenance was not such as to capture the imagination of one with research interests. However, instead of creating a separate maintenance department, headed by a man with a flair for such work, the maintenance responsibility was pyramided upon the already heavy burden carried by the factory superintendent.

A third cause of unbalance has to do with the taking on of operating responsibility by those whose role should be advisory only. Operating executives are often placed in the difficult situation of having orders issued to their subordinates by those who are staff advisers on some higher echelon. Departments created to investigate, to plan, to inspect and audit, or to keep records are subject to the temptation to intrude upon the prerogatives of operating executives who are responsible for getting work done. The ability of these executives to keep command of the situation and to retain the respect of their subordinates is undermined if departments with staff relationships are not integrated properly into the organization structure. Subordinates are confused and wonder to whom they should look as "boss" if advisory units give them orders or reprimand them. Moreover when functional control departments, like inspection and maintenance, are created, their authority to order actions taken should be defined with care.

If it is deemed necessary to permit floor inspectors to order machines shut down instantly to prevent further damage, it should be made clear that such authority does not extend to the instruction or reprimanding of the operator, or the foreman's authority will be weakened.

The respective roles of the industrial relations departments and the foremen and other operating executives illustrate the care needed in organization design if the various relationships (line, staff, and functional control) are to be delineated with precision. Top management may decide that the respective roles should be as follows:

1. The initial screening of employees being recruited by the employment manager for referral to foremen and other department heads is a functional control matter for which the employment manager must be responsible if he is to maintain the minimum hiring standards of the company.

2. The final choice of an employee to be placed in a given job is a line decision to be made by the foreman or department head, and he, rather than the employment manager, should make the decision if he is to succeed in bossing the incumbent.

3. Dismissal for cause, being a disciplinary action, is a line or bossing responsibility. The line executive who passes upon such a case may seek and receive the advice of the director of personnel, but a line executive should do the actual discharging, subject, of course, to whatever appeal machinery has been created to protect the employees against unjust decisions.

4. Determination that certain employees need training is a line matter that should be decided by a line supervisor, but the industrial relations department should advise as to the method of training that is best suited to the case.

Situations to which the organization must be adapted. Certain situations encountered in everyday business life that influence organization structure are summarized below:

1. The necessity of directing and controlling a large number of workers.

2. The importance of stressing the subdivision of labor for the purpose of developing specialized skill to obtain economy and quality, as in meat-packing or automobile plants. Such companies need many functional departments.

3. Emergencies, such as fires, in which the time element is all important and in which authority must be centralized at the scene of action.

4. Situations in which the product is highly diversified and the knowledge decentralized, as in a plant producing miscellaneous electrical instruments. They often require both functional departments, and some organization on a product basis.

But the conditions under which a business operates are subject to continual change. Consequently, the organization structure should be a flexible arrangement connecting the chief executive with the work itself, and relieving him of those cares that the chief executive would otherwise have to shoulder himself. Because an executive may die or lose his usefulness, the structure should be molded primarily to suit the work rather than the abilities or desires of certain key men. It must be recognized, however, that perfect balance in the organization structure is often sacrificed to take advantage of the peculiar abilities of certain individuals. In small companies, the human capacities are much more important than the type of organization; in large companies, however, it becomes essential to have a sound and well-balanced organization, or even the strongest men may be hampered through lost motion.

Questions:

1. Prepare an organization chart for an athletic team, showing the relationships among coaches, managers, captain, and players.

2. If you were setting up an organization to manage an outing for several hundred people, what advantages would you secure from dividing the work into a number of jobs? What disadvantages?

3. Under what circumstances would you use an exceptionally strong executive at the sacrifice of organizational balance?

4. Analyze the extent to which each of the several bases for departmentalizing appears in the organization charts in this chapter.

5. How should an excessive "span of control" be corrected?

6. What functions of a fraternity are usually controlled by the national headquarters?

CHAPTER 28

Operating Aspects of Organization

The distinction between the structural and operating aspects of organization is fundamental to successful administration. The structure is static by nature. Day-to-day operation is dynamic. It involves dealing with a great variety of human beings at all levels of authority through the making of decisions and policies, the issuance of orders, the creation of systems to substitute orderly procedure for chaos, the checking up on performance, the giving of praise when merited, and the issuance of reprimands if they are necessary. It is this dynamic phase of an organization that gives it life.

Maintenance of integrity of the organization structure. Meaningless indeed would be a structure designed to be logical and well balanced if personal desire, whim, or weakness were allowed to distort it. Perhaps the point can be clarified best by examining the relations between personnel and operating executives. Personnel men have frequently intruded upon the province of line executives, or the line executives have abdicated their authority.

Sometimes those with staff relationships have misunderstood the nature of their assignments; sometimes they have been avid to give orders as well as advice; sometimes they have felt quite honestly that they must intrude on line authority because operating executives were not discharging their responsibilities properly. They have failed to remember that as advisors, or coaches, they should not try to assume the role of players on the field.

But frequently department heads have abdicated by relinquishing their authority. Busy with a host of problems, foremen, superintendents, and works managers have sometimes turned to the personnel department to take over troublesome tasks, such as dealing with an employee dissatisfied with his job or pay. They have invited the employment department to make the final selection of employees for the jobs under their jurisdiction, thereby acquiring an alibi in case the employees fail to measure up to the requirements.

The General Motors Corporation has made clear the role that it expects its foremen to play in industrial relations.

> They have full authority to approve or disapprove the hiring and to supervise the work and make work assignments to the employees under their supervision. They initiate wage increases. They are directly responsible for the efficiency and safety of their groups. They have full authority when necessary to take immediate, appropriate disciplinary action for violation of shop rules, and other improper conduct of their employees. They are the first point of management contact and make the first management decisions on all matters relating to the employees under their jurisdiction.

Still another cause of loss of integrity of the structure is a failure to adhere to organization channels. Superiors sometimes by-pass immediate subordinates by giving orders or reprimands to employees that are supposed to be under the jurisdiction of those subordinates. Or they yield to the temptation to give decisions to employees who have by-passed their immediate bosses, as when a superintendent tells an employee he can take a day off without the foreman having been a party to the decision.

The undermining of the prestige of the foreman and even of higher factory executives is particularly in evidence in some union shops. The union officers who have been engaged in negotiating a new agreement, or in discussing a grievance with top management frequently inform the union members of the decisions reached before management informs its supervisors. The latter are thus placed in the embarrassing position of being unable to comment when their employees raise questions.

Informal cross contacts. Prior to this discussion, emphasis has been placed upon maintaining the integrity of the formal structure. In practice informal contacts are essential for flexibility and high morale. It is too time-consuming for all matters to be referred, step by step, to higher authority for decision or for transmittal to other branches of the business. Speedy action requires a "short circuiting" of the established lines of authority by personal contacts that apparently violate the regular chain of command. Dealings between the purchasing agent and the works manager, the sales and credit managers, the foremen and the personnel manager call for an infinite number of conferences, phone calls, and memoranda. A large part of the transactions of a company involve such relationships and are accomplished by short circuiting the formal channels. Were this not so, the top executive would be over-burdened with the mass of detail that is cared for in this informal manner.

Informal dealings, however, must give way to formal ones that move up and down the established channels of the structure, whenever reprimanding or discipline is involved. To call on the carpet an employee who is in another division of the business by-passes the employee's own supervisors and weakens their prestige.

Informal organization. Simple observation will confirm the fact that people in frequent contact on the job interact with each other, form into groups, and develop common patterns of reaction and conduct. These crystallized groupings and accepted modes of action come to have the enduring characteristics of office or shop traditions, customs, or mores. They spring into being without logical or conscious design. They are based rather on sentiment, emotion, likes and dislikes, predilections, and prejudices. What is not so fully understood is their dominant role in conditioning the attitudes and responses of the group. It is these contacts and reactions that constitute informal organization.

Chester I. Barnard, president of the Bell Telephone Company of New Jersey, clarified the significant relationship between formal and informal organization both among the executives and the rank-and-file. In his *Functions of the Executive* he defines informal organization as "the aggregate of personal contacts and interactions and the associated groupings of people that occur and continue or are repeated without any specific conscious joint purpose. Though common or joint purposes are excluded by definition, common or joint results of important character nevertheless come from such organization." [1]

Informal organization is the inevitable concomitant of group activity; it is an intricate social system established unconsciously by the employees that influences their conduct sharply. In its positive aspects it plays an important part in communication, the very substance of organization; it aids in developing among employees the willingness to cooperate and the acceptance of authority without which formal organization is impossible; and it helps to preserve the individual's sense of personal integrity by seeming to give him an element of choice in his job and group allegiances.

If the informal organization is integrated with the formal organization, coordinated effort or teamwork will be maximized. Informal organization that is hostile to the purposes of the formal organization hinders teamwork. Nor can it be guided into more purposive directions by sheer command and directive order through formal organization channels.

Rothlisberger and Dickenson, in their Western Electric study, discovered that informal organization [2] served two major purposes: the protection of the group against disloyalty

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[1] Chester I. Barnard, *Functions of the Executive*, page 122. Cambridge: Harvard University Press, 1940.

[2] F. J. Roethlisberger, and W. J. Dickenson, *Management and the Worker*. Cambridge: Harvard University Press, 1939.

of its members, and the protection of the group from outside interference. Balance within the group was based on certain codes of acceptability. When this code was breached, the offending member was ostracized and the balance restored by his exclusion. If supervision handed down an order that threatened the security and balance of the group, it used every artifice in its defense. The code of acceptance for one group was found to be as follows:

1. You should not turn out too much work. If you do, you are a "rate-buster."
2. You should not turn out too little work. If you do, you are a "chiseler."
3. You should not tell a supervisor anything that will react to the detriment of an associate. If you do, you are a "squealer."
4. You should not attempt to maintain social distance or act officious. If you are an inspector, for example, you should act like one.

In the case of one group that restricted output, the explanation was not a malicious and hostile attitude toward management, but rather an overwhelming desire to maintain the social organization. Individuals recognized the discrepancy between what they were doing and what they should do, but yielded to the greater pressure of the informal organization. Supervision had small chance to counteract this soldiering by orders, reprimands, and moralizing.

Again, the supervisor in some situations was found to be in the power of the informal organization of his supposed subordinates. Although there was no basic opposition to management, his subordinates considered that he was against them if he attempted to interpret or uphold management's position.

Informal organization is illogical, irrational, and the product of sentiment and emotion. It can bring about reactions in consonance with the objectives of formal organization, or it can nullify them.

The exception principle. The importance of saving the time of major executives requires the use of the exception principle. A person responsible for the conduct of large affairs, whether or not they fall in the field of business, soon learns that his effectiveness is limited if he attempts to take care of all details personally. Consequently, he must rely upon others to attend to matters that repeat themselves or that are relatively unimportant. Only thus may his own time be conserved for those matters with which he alone can deal. The device by which most executives conserve their time is termed the "exception principle," which means merely the delegation to others of recurring matters. Once the executive sees that the recurrence will be frequent, he establishes a policy and routine as a guide to handling such situations and then delegates the responsibility for dealing with them to subordinates. He is thus able to concentrate his attention upon emergencies, special questions, and new problems.

It is evident from the foregoing discussion that such delegations as we have described can take place satisfactorily only after due attention has been given to certain prerequisites:

1. Placing subordinates at key points, who have sufficient capacity and training.
2. Establishment of adequate systems.
3. Determination of policies where needed.
4. Provision of enough records and reports to indicate whether the system and rules are followed, and whether or not the assigned tasks are performed.

The exception principle, therefore, may be thought of as the capstone of a well-developed management in which are evident proper division of responsibility, clearly defined authority, and capable executives whose activities are coordinated into a smoothly working team.

If the time of high-priced major officials is to be conserved for important matters only, the multitude of unimportant items that repeat themselves day after day must be taken care of by the clerical staff and by subexecutives according to a definite procedure, called a system. A system may be defined as any orderly method or procedure. It may be so simple as to be ineffective, or so intricate as to create red tape. However, if the same routine, whether good or bad, is followed repetitively, it is a system.

Much of the same function is performed by policies, which are of the utmost importance as guides to executives in making consistent decisions. If well considered, policies prevent mistakes, and help to bring into an organization the sense of direction that is so necessary for consistency and progress. Policies may be either written or unwritten, and may be classified as major or minor, according to their relation to the company's well-being. Unless he is a complete opportunist, every executive follows policies of some kind. The important point is that policies should be logical, farsighted, and in accordance with the facts in so far as they are known. Consequently, a cardinal principle of management is that a business should be guided by policies that are clear-cut and definite, that represent the best thinking of its executive group, and that are formulated before action is taken.

Policies have been classified into three types: basic, general, and departmental. Basic policies establish the broad, long-run objectives of the company. Ordinarily they are established or at least approved by the board of directors because they affect so significantly the respect in which the company is held by its customers, employees, and the community. An example of a basic policy is that governing the relation of the level of wages to the prevailing rates in the locality. General policies also apply to the company as a whole but, unlike the basic ones, are subject to change from time to time. The distinction turns on the degree of permanence. An illustration is the general policy to spread work by shortening the work week. Departmental policies are applicable to portions of a company, such as a single plant, division, or department.

Records and reports are the fourth leg upon which the exception principle rests. Reports indicate to a superior whether or not particular missions assigned by him have been carried out. Moreover, records of performance flowing up the channels of command from each level of authority to those above enable an executive to spot those particular features of his activities that call for correction. By analyzing comparisons between actual and planned results, and between actual performance and "standard," he can pass over those operations that are satisfactory and concentrate on those that call for action.

Decision making and order giving. Decision making is at the very heart of operating through an organization. "To decide" is the briefest possible description of an executive's duties. The decision is the point at which action starts. How decisions are made and communicated is therefore of fundamental importance.

The preparatory work incident to the rendering of a decision may be done by someone other than the executive who "makes" it. The idea from which the decision stems may have come from a subordinate several echelons below him, or from a fellow executive on the same level, or one on a level above him. The development of the idea may require a long period of patient analysis and investigation that takes form in a written report setting forth the pros and cons and the supporting evidence. Or the development may be as brief as a suggestion made orally, with little or no explanation. In short, the decision itself may be the the culmination either of exhaustive study or of "snap judgment."

The decision converts study and planning into action. It is a manifestation of authority and automatically involves the assumption of responsibility for the outcome. In that moment of time when an executive decides "yes" or "no" he commits himself and the forces at his disposal. If proven correct by subsequent events, his decision adds luster to his reputation; if proven wrong, both his reputation and his company may suffer. The challenge of an executive position is that it involves an unending stream of decisions, many of which must be made in the absence of all the facts that would be desirable. Since delay may stop the efforts of many colleagues, the decision must often be made on the basis of judgment alone or on a combination of facts and judgment. When time is of the essence, the willingness to act, even at some risk, is an essential to executive success.

Once the decision is made, the maker issues orders to carry it out. These orders may be oral or written and signed by the responsible executive. Obviously, whatever communication passes between the superior and the subordinate reveals to the subordinate the caliber of the superior's mind. Such discussion should give the subordinate a clear idea of what is required. Consequently, the order should be sufficiently specific, so that the subordinate receives any information that was available to the superior officer but not to him. On the other hand, if the order is overly specific and detailed, the subordinate may feel restrained from using his initiative. Provided the subordinate has had experience and training, the order should indicate what is to be done, but the choice of methods should be left to him. Moreover, an order should never be issued if an executive does not have the necessary authority, or if it is evident that circumstances will prevent the order from being carried out.

Whether an order is given orally or in writing, whether it is a specific order for a given task or a standing order of general import, the essential characteristics of a well-conceived order are clarity and completeness. Clarity is the product of logical thinking on the part of the issuing executive, and if he has thought carefully, the orders are likely to be brief. Moreover, the language used and the manner in which the instructions are given have much to do with the attitude with which the recipient begins his task. Furthermore, if orders are issued so frequently that neither the issuers nor the receivers are likely to remember precisely what is said, written orders are advisable. Such orders not only prevent misunderstandings at the time of transmittal, but protect both parties in case of later controversy.

Motivation and indoctrination. A definite goal and the stimuli to achieve it play large roles in administration. A clear definition of the objectives must be translated into major policy, which is the governing authority of an enterprise. Adherence to policy unifies all activities into a coordinated program. If the myriad decisions made daily in a large company are to conform to major policy, those who make them must be thoroughly indoctrinated as to basic objectives and policies. This indoctrination may result from long experience, or it may be accelerated by executive conferences and even by formal training. For the indoctrination to be effective requires that the board of directors, and especially the chief executive officer, have a clear and explicit concept of the goal of the enterprise and of the basic policies incident to it.

But indoctrination alone is insufficient. Top executives must be able to motivate others to action. They must themselves have such interest in and enthusiasm for the common purpose that they regard their jobs as opportunities challenging their best efforts, and not as routine chores performed in return for a pay check. The motivation of others calls sometimes for the ability to induce by persuasion and sometimes for the driving power that will impel others to overcome obstacles.

Leadership the *sine qua non* of organization. Since business conditions are subject to constant change, leadership is essential for effective control under shifting conditions. It must be evident that no reorganization, however thorough, or no organization chart, however well designed, can replace the leadership and driving power of executives in key positions. Sound organization is of great help as a supplement to leadership, but it can never suffice as a substitute.

A leader may be defined as one who has a program and can induce others to follow him. As Mr. Ordway Tead has expressed it, "Leadership is that combination of qualities by the possession of which one is able to get something done by others, chiefly because through his influence they become willing to do it." Both in and out of business, leadership takes a variety of forms. In industry, it is needed in some degree in all jobs from that of gang boss to chairman of the board, but the qualities required of leaders at these various levels are quite different. A person adapted to one job is not necessarily adapted to another. Leadership, therefore, is related to particular situations, and it is almost futile to talk about leadership traits in general. Dr. W. H. Cowley has pointed out that an executive may sometimes be a leader and sometimes only a "headman." The term leader implies that the person has a program and can succeed in persuading others to follow him. In contrast, a headman is a person who, because of some combination of factors, has attained a position of authority and headship without being a leader. Only when a well-equipped man occupies a position to which he is suited is leadership at its best. The leaders in the field of scientific research are of a type very different from steel-mill superintendents and the heads of large selling organizations.

Before the possibility of developing leadership in executives and subexecutives can be considered, it is important to recognize that some of its elements are intellectual, whereas others are associated with character and personality. The ability to command respect is an essential feature of leadership in any walk of life. In business, leadership depends chiefly upon two factors: a man's mastery of his job and the possession of sound business judgment. Of course, mere mastery of a job does not of itself make a leader, but it is an essential part of a leader's equipment. Neither does mere good judgment in a person make him a leader; nevertheless, in the field of business it is difficult for an executive to retain the respect of his colleagues unless he is a clear thinker and a skillful planner. He needs the imagination and the special knowledge necessary for the exercise of foresight in order to avoid emergencies calling for quick—and often poor—decisions, merely because the situations were not anticipated.

The statement is often made that leaders are born, not made. To the extent that leadership depends upon native talents, this statement is doubtless true. On the other hand, even those characteristics that have to do with personality are subject to the influence of environment. For example, Theodore Roosevelt in early life was a puny individual in contrast with the aggressive, vigorous man he became when mature. Moreover, those intellectual traits needed for judicious planning can clearly be developed through training. At the very least, one can learn to distinguish between facts and opinions.

It must not be supposed that leadership is a matter of mere popularity, especially if the latter has been achieved by easygoing methods or favoritism. When the real test comes, such popularity may end in insubordination. Nor are those manners associated with the dyspeptic essential for being a good boss. What is usually needed is, rather, an executive who has emotional stability and evenness of manner, but "iron" enough not to flinch at making difficult and important decisions.

In the exercise of executive control, leadership plays an important part in the coordination of divergent points of view. It is likewise essential if policies are to be thought out and decided upon in advance, so that as many pitfalls as possible may be avoided. Moreover, leadership occupies a key position in the building of morale, for it is the spirit that gives life to an organization. Business management knows no substitute for first-class human ability.

Questions:

1. Having once delegated authority through the superintendent to the foremen, should the general manager give orders directly to one of the workers? Should he question such a worker or permit the latter to discuss the work with him when the foreman is not present?

2. If you had been planted by the President in a department to solve

its problems, would you sell your ideas for improvement to your superior or report to the President directly?

3. To what extent is promotion from within dependent upon a program of training?

4. Should a methods engineer suggest changes in the design of product to the designer on the drafting board?

5. What is the strength and weakness of an order of the "message to Garcia" type?

6. How are policies, procedures, and indoctrination related to the exception principle? To achieving coordination?

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