PRINCIPLES OF INDUSTRIAL ENGINEERING

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PRINCIPLES

OF

INDUSTRIAL ENGINEERING

BY

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PREFACE

The subject matter of this book is substantially the text of a series of lectures prepared under the auspices of the Department of Mechanical Engineering of Columbia University, for delivery to senior students. As here presented, it takes the form evolved from three years' experience in the class-room at Columbia, somewhat modified from the manner of the lecture platform, and adapted to meet the needs of a more general study as discovered by contact with non-technical audiences at Harvard and the New York University, and by many inquiries addressed to the Editorial Department of *The Engineering Magazine*.

The original purpose when the work was undertaken at Columbia in 1908–09 was to lay the foundations for a composite course in Works Management, in which several eminent practitioners should follow with successive portions of the main structure. Experiment showed, however, that the better plan was to give these preparatory essays rather the character of a primary triangulation, covering the whole province, though it might be only in very broad outline. Further detail might then be filled in sectionally, as expedient, by specialists, each in his own subject. Thus, the discussion now reduced to printed chapters, was to be co-ordinated with certain lectures by Charles U. Carpenter, on factory and commercial organization; by Harrington Emerson, on the philosophy of efficiency; by H. L. Gantt, on scientific management; by R. T. Lingley, on factory accounting. It has not seemed feasible to co-ordinate these other lectures here so that the volume might present the entire argument. Several of the collaborators have published independently even fuller expositions of their thought on the special topics, and reference to these will be found throughout the book.

This volume is therefore put forth to serve in a wider sphere the same function it served in the Columbia course — that of affording a carefully chosen standpoint from which to view the principal factors in the industrial problem, their relations and influence, and the properties and efficacies of the more important solutions so far proposed.

The scale, as already said, is broad. The study is directed almost wholly to the discovery and definition of ideals and principles, or in some cases of institutions; very little attempt is made at the description of methods and devices. The book advances no claim of exhaustiveness, but only of an earnest effort to maintain a just scale of proportion, and to trace an outline of the province it undertakes to delimit, by which the student of industrial engineering may safely orient himself in his further and closer examination of the subject.

C. B. G.

May, 1911.

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CHAPTER I

THE ORIGIN OF THE INDUSTRIAL SYSTEM

INDUSTRIAL engineering is the formulated science of management. It directs the efficient conduct of manufacturing, construction, transportation, or even commercial enterprises — of any undertaking, indeed, in which human labor is directed to accomplishing any kind of work. It is of very recent origin. Indeed, it is only just emerging from the formative period — has only just crystallized, so to speak, from the solution in which its elements have been combining during the past one or two decades. The conditions that have brought into being this new applied science, this new branch of engineering, grew out of the rise and enormous expansion of the manufacturing system. This phenomenon of the evolution of a new applied science is like those that have been witnessed in other fields of human effort when some great change, internal or external, forced them from a position of very minor importance into that of a major service to civilization. Columbus could blow across the ocean in a caravel to an unknown landfall; but before a regular packet service could be run between New York and Liverpool navigation must be made a science. It has drawn upon older, purer sciences for its fundamental data — upon astronomy, meteorology and hydrography, and later upon marine steam engineering and electricity; but out of all these it has fused a distinct body of science of its own, by which new practitioners can be trained, by which certainty, safety and efficiency of performance may be substantially assured.

Navigation is not merely making correct observation of the sun and stars, of lights and beacons, of log and lead; it is not merely directing the propelling and steering machinery; it is not merely knowledge of courses and distances; it is not merely storm strategy. It is the co-ordination of all these in handling the equipment provided by the marine engineer and naval architect, through the work of a crew of men.

In somewhat like manner, industrial engineering [1] has drawn upon mechanical engineering, upon economics, sociology, psychology, philosophy, accountancy, to fuse from these older sciences a distinct body of science of its own. It does not consist merely in the financial or commercial direction, nor merely in running the power-plant or machinery, nor merely in devising processes or methods. It consists in co-ordinating all these things, and others, in the direction of the work of operatives, using the equipment provided by the engineer, machinery builder, and architect.

The cycle of operations which the industrial engineer directs is this: Money is converted into raw materials and labor; raw materials and labor are converted into finished product or services of some kind; finished product, or service, is converted back into money. The difference between the first money and the last money is (in a very broad sense) the gross profit of the operation. Part of this is absorbed in the intervening conversions, or, in other words, in the operations of purchase, manufacture, sale, and the administration connected with each.

[1] A systematic presentation of the field of industrial engineering from an entirely different point of view and by a very different method will be found in "Factory Organization and Administration," by Prof. Hugo Diemer; McGraw-Hill Book Co.

Now the starting level (that is, the cost of raw materials and labor) and the final level (the price obtainable for finished product) — these two levels are generally fixed by competition and market conditions, as surely and as definitely as the differences in level between intake and tail race are fixed in a water power. Hence our profit, like the energy delivered at the bus bars, varies not only with the volume passing from level to level, but with the efficiency of the conversions between these levels. In the hydroelectric power-plant, the conversion losses are hydraulic, mechanical and electrical. In any industrial enterprise the conversion losses are commercial, manufacturing, administrative. It is with the efficiency of these latter conversions that industrial engineering is concerned.

The industrial engineer may have in his organization staff many mechanical engineers superintending special departments — design or construction, or the power-plant, for instance — while his own duty is to co-ordinate all these factors, and many more, for the one great, central purpose of efficient and economical production. He is concerned not only with the direction of the great sources of power in nature, but with the direction of these forces as exerted by machinery, working upon materials, and operated by men. It is the inclusion of the economic and the human elements especially that differentiates industrial engineering from the older established branches of the profession. To put it in another way: The work of the industrial engineer not only covers technical counsel and superintendence of the technical elements of large enterprises, but extends also over the management of men and the definition and direction of policies in fields that the financial or commercial man has always considered exclusively his own.

In general, the work of the industrial engineer, or, to use a yet more inclusive term which is coming into general use, the efficiency engineer, has two phases. The first of these is analytical — we might almost call it passive to distinguish it from the second phase, which is synthetic, creative, and most emphatically active. The analytical phase of industrial or efficiency engineering deals merely with the things that already exist. It examines into facts and conditions, dissects them, analyzes them, weighs them, and shows them in a form that increases our useful working knowledge of the industry with which we have to deal. To this province of industrial engineering belong the collection and tabulation of statistics about a business, the accurate determination and analysis of costs, and the comparison of these costs with established standards so as to determine whether or not they are normal. To this sort of work Harrington Emerson applies the term "assays," speaking of labor assays, expense assays, etc., and maintaining (with good reason) that the expert efficiency engineer can make determinations of this sort as accurately, and compare them with standards as intelligently, as an assayer can separate and weigh the metal in an ore. To this province belong also such matters as systematic inquiry into the means and methods used for receiving, handling, and issuing materials, routing and transporting these materials in process of manufacture, the general arrangement of the plant, and the effect of this arrangement upon economy of operation. To this province belongs, also, the reduction of these data and other data to graphic form, by which their influence and bearing upon total result are often made surprisingly and effectively manifest. It is wonderful how much new knowledge a man may gain about even a business with which he thinks he is thoroughly familiar by plotting various sorts of data on charts where, say, the movement of materials back and forth, or the rise of costs under certain conditions, are translated immediately into visible lines instead of being put into the indirect and rather unimpressive form of long descriptions or tabular columns of figures.

The great purpose and value, indeed, of these analytical functions of industrial engineering is that they visualize the operations of the business and enable us to pick out the weak spots and the bad spots so that we can apply the right remedies and apply them where they are needed. They make us apprehend the presence and the relative importance of elements which would otherwise remain lost in the mass, undetected by our unaided senses.

The second phase of industrial engineering — the active, creative and synthetic phase,— goes on from this point and effects improvements, devises new methods and processes, introduces economies, develops new ideas. Instead of merely telling us what we have been doing or what we are doing, it makes us do the same thing more economically or shows us how to do a new thing that is better than the old. To this part of works management belongs, for example, the rearrangement of manufacturing plants, of departments, or of operations so as to simplify the process of manufacture; the correction of inefficiencies, whether of power, transmission, equipment or labor; the invention and application of new policies in management which make the ideals and purposes of the head operate more directly upon the conduct of the hands; the devising of new wage systems by which, for example, stimulus of individual reward proportioned to output makes the individual employee more productive.

The exercise of these functions, whether analytical or creative, by the industrial engineer or the efficiency engineer, requires that he shall have technical knowledge and scientific training, but in somewhat different form from the equipment of the mechanical engineer and somewhat differently exercised.

Industrial engineering deals with machinery; but not so much with its design, construction, or abstract economy, which are strictly mechanical considerations, as with selection, arrangement, installation, operation and maintenance, and the influence which each of these points or all of them together may exert upon the total cost of the product which that machinery turns out.

It deals with materials, but not so much with their mechanical and physical constants, which are strictly technical considerations, as with their proper selection, their standardization, their custody, transportation, and manipulation.

It deals very largely with methods; but the methods with which it is particularly concerned are methods of performing work; methods of securing high efficiency in the output of machinery and of men; methods of handling materials, and establishing the exact connection between each unit handled and the cost of handling; methods of keeping track of work in progress and visualizing the result so that the manager of the works may have a controlling view of everything that is going on; methods of recording times and costs so that the efficiency of the performance may be compared with known standards; methods of detecting causes of low efficiency or poor economy and applying the necessary remedies.

It deals with management — that is, with the executive and administrative direction of the whole dynamic organization, including machinery, equipment and men.

It deals with men themselves and with the influences which stimulate their ambition, enlist their co-operation and insure their most effective work.

It deals with markets, with the economic principles or laws affecting them and the mode of creating, enlarging, or controlling them.

The most important elements of industrial engineering are summed up in this alliterative list — machinery, materials, methods, management, men and markets. And these six elements are interpreted and construed by the aid of another factor whose name also begins with m — Money. Money supplies the gauge and the limit by which the other factors are all measured and adjusted. This of course is true not alone of industrial engineering; the civil engineer, the mechanical engineer, the electrical engineer, the mining engineer, each and all must normally be expected to make money for his employer or client. One of the simplest principles of the profession, but one which the mere technician sometimes finds it hardest to keep in mind, is that the primary purpose for which the engineer is usually engaged is to direct the employment of capital so that it may pay back dividends to its owners. And while this is generally true of all engineering employment, it is most particularly, continuously and everlastingly true of works management. It is much easier to conceive of the civil engineer or the mechanical engineer being retained to carry out some piece of work in which scientific accuracy is demanded regardless of cost, than it is to conceive of a shop superintendent being directed or even permitted to manufacture a line of product regardless of cost.

It is the ever-present duty of the industrial engineer, of the efficiency engineer, to study constantly, and to study constantly harder and harder, the question of equivalency between the dollars spent and the things secured. It is not sufficient, for example, for him to know that a machine sold for $100 costs $75 to make. This may be a very good profit and the machine itself may be an excellent one. There may be vouchers honestly connecting every cent of the $75 cost with some actual item of material, labor, or expense. Nevertheless, the industrial engineer must constantly look back of these figures to see whether by some change of machinery, some modification of materials, some alteration of methods, some higher skill in management, some stimulus to the men, he can make the machine cost less than $75 for its manufacture, or can make it a better machine for the same cost, or perhaps can do both.

In short, the industrial engineer is under unending and unremitting pressure to secure a true proportion between what he spends and what he gets. And the proportion is never true so long as the smallest opportunity remains for getting more in return for what he spends, or for spending less in payment for what he gets. The function of the industrial engineer is to determine with the utmost possible wisdom and insight whether and where any disproportion between expenditure and return exists, to find the amount of the disproportion, the causes of such disproportion, and to apply effective remedies.

The forces causing this pressure for the reduction of cost are principally two. The older and cruder is competition. The later and larger, which in itself carries the answer to competition, is the effort toward efficiency.

Competition was not created by the manufacturing system. It existed from the foundation of the world. But it took on a new meaning and new activity when the things began to be made first and sold after (as they are under the manufacturing system) instead of being sold first and made afterward, as they were under the older order. If you contract to buy something which is not yet in existence — a bridge, a house, a suit of clothes, or what not — the bargain is largely a matter of estimate, often, indeed, a matter of guesswork, on both sides. You have to strike a mental balance between the several alternatives presented and compare in your mind net results of cost, design, quality, certainty and promptness of delivery, personality, credit, and perhaps many other things, some of them intangible, and some only to be proved by the outcome. The proposition that seems most attractive is closed; the competing ones are never carried out at all. The buyer never can tell with absolute certainty whether or not he got the best value for his money; he can only compare the thing which has been made with what he thinks the other things would have been if they had been made. The seller does not know until everything is over whether or not he made a profit, or how much. But when you sell things already made, like lathes or high-speed engines or dynamos, off the sales-room floor, the prospective buyer can make the most absolute and intimate comparison between the things and their prices. He can compare Brown & Sharpe with Lodge & Shipley, Harrisburg with the Ball engine, Westinghouse with Crocker-Wheeler. He can compare accurately design, quality, cost before a word or a dollar passes. The necessity for offering the best goods for the least money and yet making a fair profit becomes vital and insistent, and so the knowledge of actual costs and the ability to reduce costs become fundamental. Competition has therefore been in one way a tremendous force for economy in manufacturing. And yet, by a paradox, in another way competition has been one of the great sources of waste, by causing duplication of plant, of organization, of equipment, of sales effort, and of middle-men — none of which may have any better reason for existence than someone's desire to share in tempting-looking profits, but all of which must be paid by the consumer — all of which become a burden on society at large.

The new and ethically fine ideal, therefore, is efficiency — the reduction of costs and the elimination of waste for the primary purpose of doing the thing as well as it can be done, and the distribution of the increased profits thus secured among producer, consumer, and employee. Efficiency is a concept as much finer than competition as creation, conservation, is finer than warfare. It is a philosophy — an interpretation of the relations of things that may be applied not only to industry but to all life. Let me quote a few sentences from Harrington Emerson's "Efficiency as a Basis for Operation and Wages":

"If we could eliminate all the wastes due to evil, all men would be good; if we could eliminate all the wastes due to ignorance, all men would have the benefit of supreme wisdom; if we could eliminate all the wastes due to laziness and misdirected efforts, all men would be reasonably and healthfully industrious. It is not impossible that through efficiency standards, with efficiency rewards and penalties, we could in the course of a few generations crowd off the sphere the inefficient and develop the efficient, thus producing a nation of men good, wise and industrious, thus giving to God what is His, to Cæsar what is his, and to the individual what is his. The attainable standard becomes very high, the attainment itself becomes very high. . . .

"Efficiency is to be attained not by individual striving, but solely by establishing, from all the accumulated and available wisdom of the world, staff-knowledge standards for each act — by carrying staff standards into effect through directing line organization, through rewards for individual excellence; persuading the individual to accept staff standards, to accept line direction and control, and under this double guidance to do his own uttermost best."

Efficiency, then, and in consequence industrial engineering, which is the prosecution of efficiency in manufacturing, involves much more than mere technical considerations or technical knowledge. If we consider the way in which the manufacturing system came into existence, we can quite easily and clearly discover its most important elements; we shall see particularly something that it is of the utmost importance for us to understand, and that is that it did not originate in technical advances alone, and it has never depended upon technical advances alone, but it has been influenced at least in equal and perhaps in larger proportion by economic or commercial conditions, and by another set of factors which are psychological — that is, which have to do with the thoughts and purposes and emotions of men.

The point is very important, because true and stable industrial progress, whether for the individual, the manufacturing plant or corporation, or the nation at large, depends upon a wise co-ordination and balance between technical, commercial, and human considerations. It is frequently necessary in addressing a commercial audience to emphasize the importance of the technical element. Before a technical audience, on the other hand, emphasis must often be laid on the commercial and psychological factors that in practical achievement must always be interwoven with the technical factor. Every great industrial organization and every great step in industrial progress to-day includes all three elements, but they will perhaps appear more distinct if we look at the origin and source of the manufacturing system, out of which this new science of industry has sprung. The origin of the manufacturing system was clearly enough the introduction of a group of inventions that came in close sequence about the end of the eighteenth century and beginning of the nineteenth. These were the steam engine, mechanical spinning and weaving machinery, the steamboat, the locomotive, and the machine-tool. It is commonly assumed that the great cause of the entire movement was Watt's improvement of the steam engine — that the industrial era which began a little more than a century ago was, so to speak, waiting in suspense, in the hush of things unborn, ready to leap into being as soon as the prime mover had been perfected to a point of practical service.

This view seems to be incomplete. The steam engine had been discovered, forgotten, and rediscovered, it would be difficult to say how often, from the time of Hero or earlier down to the time of Watt — forgotten and ignored because the world had no use for it; the economic conditions were not ripe for it. If there had been the same demand for power to pump the mines in England, the same demand for machinery in the textile industries of England, the same need for better vehicles to transport commercial products by land and by sea, in the time of Papin or the Marquis of Worcester that there was in the time of Watt, I think it is quite conceivable that the inventions which made Watt famous would have come a full century earlier, and his genius would have been exerted upon a later stage of the problem, as the genius of Willans and Corliss and Parsons and Curtis has been within the period of our own lives.

I am strongly inclined to believe that the world has always had something near the quality and quantity of engineering talent it has been able to use. When civilization was dependent chiefly upon roads, aqueducts, bridges and buildings, it got them. We have never done some of these things better, technically speaking, than the Assyrians, or the Romans, or the architects of the great cathedrals of the middle ages; some, indeed, we perhaps never shall do again as well. Newcomen, Watt, Arkwright, Stephenson, Bessemer, applied genius to a new sort of opportunity, rather than embodied in themselves a new order of genius. They may indeed have been greater than other workers who preceded them, but the more important element in their success is that the world was at last ready and waiting as it never had been before for the peculiar product of genius they had to offer. This readiness that opened the door to their success was due to economic or commercial conditions, not merely to the technical invention. In its larger relations, then, technical success depends upon commercial opportunity. There must be a potential market. Bessemer steel could not have found any welcome in the Stone Age. The typewriter would not have succeeded in the dark ages when no one but a few clerics could read and write. Savages who traded cocoanuts for beads and brass wire could afford no encouragement to the manufacturer of the cash register or the adding machine. It was not because of thermodynamic inefficiency that Hero's engine failed of adoption. On the other hand, when the world was ready for steam power it accepted very gladly to begin with a very crude machine, and technical improvement went step by step with larger practical utilization, sometimes leading and sometimes following. There must, then, be a potential market or application, or advance in the applied sciences will be limited. This is an axiom to be placed alongside of another — that there must be scientific study and research, or industries based upon the applications of science will stagnate and remain at a low stage of efficiency.

The second factor in industrial progress, then, is the commercial factor. There must be a potential market; but it does not follow from this that technical progress is wholly subordinate to economic conditions. The inventor or the engineer is not of necessity merely a follower of progress in commerce or industry. Many of the great advances in applied science, or in branches of industrial achievement perhaps too lowly to be called applied science, have been made by man who foresaw not only technical possibilities but commercial possibilities — who undertook not only to perfect the invention but to show the world the advantage of using it. I think this was substantially the case with wireless telegraphy, with the cash register and typewriter. Nobody had demanded these things because nobody had thought of them, and the productive act in each instance included not only technical insight into the possibilities of doing the thing, but human insight into the fact that people would appreciate these things and use them if they could be furnished at or below a certain cost. Modern industrial methods have shown us that in many cases there is no such thing as a fixed demand beyond which supply can not be absorbed, but that demand is a function of cost of production. There may be no demand at all for an article costing a dollar, but an almost unlimited demand for the same article if it can be sold at five cents. A large part of the work of the production engineer lies in the creation of methods by which the cost of production is decreased and the volume of production is thereby increased, with advantages to both the producer and the consumer.

In all these cases you see that technical achievement, technical success, is closely interlocked with industrial or economic conditions, and with the understanding and control of industrial or economic influences and forces.

The third factor in industrial progress is the psychological factor — the element contributed by the mental attitude, emotions, or passions of men. I might suggest its possible importance by reminding you that there were centuries in which the inventor of the steam engine, far from being rewarded, would have been burned at the stake as a magician. This would not have been because the extraordinary character of the achievement was unrecognized, but because its nature was misinterpreted. That particular form of expressing intellectual dissent has gone out of date. We are much more civilized now, and nineteenth- or twentieth-century inventors who are far ahead of their times are no longer burned; they are merely allowed to starve to death; while those who are timely, but not commercially shrewd, are usually swindled by some promoter, who in turn is frozen out by a trust. In any case, you see, the simple technician gets the worst of it industrially, not because his physical science is weak, but because his commercial and mental shrewdness is not correspondingly developed.

Taking a larger view of it, we shall see that almost every important advance in engineering progress is made only after a period of pause, an interval following proof of the technical achievement, following even demonstration of its commercial economy. We might call this the psychological lag — the time necessary for the growth of human faith sufficient to energize an industrial movement. In the case of the electric railway, or the motor vehicle, for example, this lag was measured by years. Bessemer could not convince the ironmasters of England, and had to build his own plant. Westinghouse, having gained after much difficulty an audience with the greatest railroad manager of that day, was told that this practical railroad man had no time to waste on a damn fool who expected to stop railroad trains with wind. The matter deserves emphasis because it is almost certain to enter into the individual experience of every man. You will have to make someone believe you, and believe in you, before you can get anywhere or do anything. When a technical man has a proposition to put before an individual, or a group of individuals, or society at large, he is very likely to think that scientific demonstration of its technical soundness ought to be convincing. You will find, however, that men at large will substantially ignore scientific proof, and that you must add to it, second, proof of the commercial or economic argument, and third, that psychological force which convinces not the reason, but the emotions. In all industrial engineering, which involves dealing with men, this psychological or human element is of immense, even controlling importance. The principles of the science are absolute, scientific, eternal. But methods, when we are dealing with men, must recognize the personal equation (which is psychologic) or failure will follow. The differences between the several philosophies of works management as expressed in the wage systems which we are going to consider later are psychological. Success in handling men and women, which is one of the most important parts of the work of the industrial engineer, is founded on knowledge of human nature, which is psychology.

The great industrial movement, then, with which we have to do is triune in its nature, the three chief elements being the technical or scientific, the economic or commercial, and the psychological or human. They seldom respond at equal rates to the impetus of advance. Sometimes the technician pushes so far ahead that the world loses touch with what he is doing and his work lies long unused until civilization catches up; sometimes the commercial tendency is unduly aggressive, and discourages or impedes real scientific achievement; very often the men most concerned with the industrial activities go badly wrong in their philosophy, and get disastrously false notions as to what makes for real progress and real welfare. More difficulties, perhaps, come from this cause than from any other.

To the technical man, it is an ever-present duty to keep in view absolute ideals, to seek every chance for their advancement, and to mould conditions and men so as to obtain constantly nearer approach to these ideals; but in doing this he must never forget to attach full weight to economic conditions, and he must never allow himself to ignore human nature.

REFLEX INFLUENCES OF THE INDUSTRIAL SYSTEM

CHAPTER II

REFLEX INFLUENCES OF THE INDUSTRIAL SYSTEM

IN the foregoing broad sketch of the rise of the industrial system and of the influences controlling its development, much stress is laid on the non-mechanical factors, because when we consider manufacturing as a province of engineering we are prone to think first, oftenest, and most of the technical aspects. They need no added emphasis. It is expedient rather to keep deliberately in view the other components of the new applied science of industrial management. But having made emphatic recognition and acknowledgment of the economic and psychologic factors in the movement, we may return to pay just tribute to the power and effect of the great discoveries and inventions that inaugurated the manufacturing system. The distinguishing characteristic of this system was the introduction of mechanical power and machinery in place of hand labor. Increase in complexity of industrial organization was thereby very much accelerated, and great changes were worked from which have followed many of the difficulties and also many of the advantages of manufacturing conditions to-day. For this replacement of the old handicrafts by power and machinery gave impulse to three great swiftly moving tendencies: aggregation, or progressive increase in size of the industrial unit; standardization, or the execution of work by fixed patterns; and specialization, or limitation of the work of each individual to the repetition of some small element of an entire process. Each of them has far-reaching effects, not only in the conduct of industry, but upon the social and political order. Let us consider them separately.

Aggregation is the coalescence of capital, of machinery, of operatives, into larger and larger bodies under one centralized direction. Large bodies of workers had indeed been assembled in the past for works of construction — witness the Pyramids — but the occasion was unusual. Handicrafts induced distribution rather than concentration. But when invention had given the world power-driven machines, it became frequent, then customary, then inevitable (because economical) to group them according to the largest number that could be conveniently operated by some source of prime energy — the older water-power or the newer steam-engine. In either case the result was the assembly in one establishment of a body of workers, larger or smaller, according to the mechanical and market conditions. In fact, the power-plant became the principal material factor determining the size of the industrial unit.

Before the mechanical prime-mover and the power-driven machines were put into service, in the days when the hand or the foot of the workman furnished all the motive power necessary, the industrial unit was the single workman. He was motive power, transmission gearing, and often driven machine, all in himself, and he needed no factory building other than the house in which he lived. This was the age of domestic industries. It exists to-day to some extent, side by side with the large manufacturing plant and in the midst of this factory era. Familiar examples are the Scotch weavers, the German toy makers, Swiss watch makers, and in many large cities a certain proportion of the garment workers.

It would seem as if these domestic industries should afford the most nearly ideal conditions for the welfare of the worker, and should offer least opportunity for the evils of the manufacturing system. But this supposition does not seem always to be well supported by examination of the facts. You may remember that Barrie does not draw a very happy picture of the condition of the Scotch weavers, and we do not have to go far to find that the lot of the garment worker who carries on his work in his own home is in many respects miserable. The concentration of workers into factories, it is true, caused many evils; but the very fact that the communities of workers were so large and the conditions were so difficult to conceal, of itself operated powerfully to bring about a correction of the evils. However, taking the whole range of industrial operations, and the occupations dependent upon them, one of the first and greatest of the changes occasioned by the new order was this change of concentration or aggregation. It caused a concentration of manufacturing enterprise in regions where fuel was abundant and good. It caused aggregation of capital to finance the larger and more extensive plants which became necessary when costly engines and machinery became part of the requisite equipment. It caused aggregation of workers in the buildings where work must be carried on, and in the districts available for residence in the vicinity of these works. The same principle extended its influence into the field of transportation, which became focalized at the great manufacturing centers and developed along certain lies connecting these.

This tendency to aggregation, be it noted, exists naturally as the outcome of merely mechanical or physical conditions, and even in this direction the things that set it in operation continued to act in such a way as to cause permanence and acceleration of the movement. Broadly speaking, the big factory has some advantage over the little one. Its wants are larger, its purchases greater, and hence its custom is worth more to sellers of materials and it is likely to get its supplies a little cheaper. Its fixed expenses for management, superintendence, and administration generally, are perhaps no greater absolutely than those of the small factory, and almost certainly are less per unit of product. Its influence, prestige, and control of trade connections are likely to be greater. It can frequently afford to hire better talent. It may be in position to use waste or by-products advantageously, which, in smaller quantities, can not be recovered except at expense greater than the saving. It is often in position, if wisely administered, to undersell its small competitor, and still deliver an equal or a better product.

This is not universally and unlimitedly true. There may be, and there often are, critical points at which the large manufacturer is at a disadvantage compared to the small one. But the tendency is for the big to grow bigger, and the strong to grow stronger, at some expense to the small and weak. This is true of the pickerel in the pond and of the tree in the woods. Given even *equal* brains in the management, it is true of the industrial corporation; and of course it is often, if not usually, true that the big concern attracts or can attract to its service the *best* brains in the market. I am still speaking of what we might term wholly physical tendencies. But here again the physical tendency becomes closely intertwined with another tendency, which is at last partly psychological — the tendency to association. Whenever two or three are gathered together in one place, with a common thought or sympathy, somebody with the spirit of the organizer always turns up and starts a society, or a brotherhood, or a lodge, or an order of sons or daughters of something, and soon we have nobles and princes, exalted and most worshipful grand masters, secrets, grips, passwords, and a constitution, by-laws and ritual. We find this everywhere, even when the common bond has to be artificially created. It was absolutely inevitable where great interests, vital to the well-being of the parties in question, were at stake. Here we had a vast industrial civilization growing up — legislative bodies, transportation companies, manufacturers and employees, all taking somewhat diverse views as to what was right and proper, and all striving more or less selfishly to gain as much and to yield as little as possible. It was absolutely inevitable that the units in each and every one of these parties should draw together, not only through the absorption of the lesser by the greater, but in a co-operative effort to secure, by collective bargaining, for themselves and their own interests, the greatest advantage possible. So, as a logical outcome, we have not only railway consolidation, but trunk-line pools, presidents' agreements, and traffic associations among the railways. On the part of employers, we have manufacturers' associations, syndicates, cartels and trusts. On the part of workmen we have trade unions, labor organizations and federations. In general, these things are inevitable, and they will persist. They are part of the evolution of the time, and they can not be abolished by legislation nor crushed by opposing organizations. I do not mean for a moment that they have been or are yet wholly beneficent — far from it. Trusts, when they became great enough, have proved ruthless in crushing competitors, and soulless in wringing profits from helpless customers. Labor unions have committed crimes of violence that shock humanity. Railroads have cared for neither law nor gospel in their autocratic pursuit of their own way.

But these are not the healthy, but the unhealthy, phenomena of growth and change — the abuses which seem to be always incident to a changing era. They pass and disappear with progress in the general mastery of understanding as to what is best for society at large under the new conditions. They are abated, not by arresting the whole development, and perhaps not as much as is generally thought by legislative enactment, but rather by a general change in the temper of the world, which makes the evil proceedings unthinkable and the position of the evil-doer intolerable. The world has seen again and again these outbreaks of destructive activity on the part of unscrupulous men, who are partly quicker than others to see selfish opportunities in a new condition of affairs, and partly nearer to the beasts of prey in their lack of conscience in seizing whatever their skill enables them to grasp and their strength enables them to hold.

In the days when the greatest prowess the world knew was military, it was the "man on horseback" who waded through blood to power and fortune; but it would be inconceivable that we should have another Napoleon to-day. The rise of commerce and traffic over-seas, with or without the opportunity afforded by almost continual wars and that very elastic institution known as "letters of marque," saw the development of piracy to the rank almost of a gentleman's occupation; but piracy has disappeared from the earth, or rather from the ocean. The first great era of railroad building in this country brought with it our now notorious generation of millionaire railroad wreckers; but I think we all must admit that the railroad world has purged itself pretty thoroughly of that disease, or at least that our great lines now are generally administered with honesty and faithful regard for the interests of the security holders.

It is not to be denied that the hanging of pirates and the jailing of dishonest railroad presidents has its effect in stimulating a change of sentiment; but the great cause, after all, is the altered public opinion which makes the hanging or the jailing possible. To borrow a simile from bacteriology, these poisons that germinate in the body politic, and seem sometimes to be increasing to fatal proportions, appear also to develop their own anti-toxins by which they are finally checked and destroyed. The world no longer lives in fear of an Alexander or a Napoleon, but its confidence is not based upon abolition of the military system which gained Napoleon his opportunity. We still have standing armies far more powerful than those with which Napoleon conducted his campaigns, but in general they inspire in the minds of the Nation feelings of comfort, security, and protection. I have a good deal of faith that the great captains of industry will soon learn a lesson from the past and the present which will make them as little a menace to the country's good as the captains of war now are. I think we shall eventually see that it is not a control of 25 per cent or 50 per cent of the output that makes a trust good or bad, but only its fairness towards consumer and employee, and the health and soundness of its economic policy. I think we shall find that trust managers will increasingly appreciate (as some of them do already) that their own best interests are served when they share to the largest consistent extent, with customers and employees, and through them with the public, those advantages in manufacturing which vast organized facilities give; and I think labor will realize (as some of its advanced leaders already do) that its own cause will be best furthered when it aids all sound measures and plans for increasing the efficiency of the workman, and when it seeks to exact, not as much as force can extort, right or wrong, but just what is reasonable and equitable.

This may sound like a description of the millennium; but the curve of progress made in the last few decades tends clearly in the direction I have tried to describe. There is indeed yet a long way to go. But reason and common-sense are growing more powerful year by year, and the more enlightened common-sense becomes, the more it will see that we must let those with whom we deal prosper, if we are to prosper ourselves.

At all events, the great corporations and the great labor unions are here, largely as the result of the great manufacturing plant. I do not pretend to speak *ex cathedra,* but it seems to be as futile for a manufacturer or an association of manufacturers to attempt to "smash the union," as it is for a politician or a legislature to propose to "bust the trusts." They appear to be permanent institutions —

or at least as permanent as most of our other economic institutions — and while of course their excesses must be curbed and many of their purposes must be enlightened, they are a necessary part of the age, and we must deal with them as wisely and as thoughtfully as we can, but with conviction that they are here to stay, and that whether we like it or not, they must be dealt with. Aggregation is a functional necessity, indeed an organic part, of the industrial and manufacturing system.

Specialization, the second great tendency, is the separation of work into elementary or fractional parts which are distributed to different operatives. The workman no longer produces, or even reproduces, a complete article, but only performs over and over some one of the series of operations necessary to the production of that article. This is the natural outgrowth of the replacement of the journeyman or mechanic by the machine tender. Take the case of the weaving industry as an illustration. In its primitive form, the one workman or workwoman proceeded first to card wool or flax or cotton, until there was enough to spin the yarn; then he spun yarn until he had enough to make the rug or bolt of cloth or what not he had in view; then he threaded the warp through the harness of his loom, and worked at the weaving until the job was finished. Probably he was dyer and finisher, also, when necessary. You can see this whole process carried on to-day in the log cabins of North Carolina, the farm-houses of Nova Scotia, or the hogans of the Navajo reservation.

But as soon as the industry is taken away from hand workers and given to machines, the operations of carding, spinning and weaving are split up between at least three and probably more than three different pieces of apparatus, which means three or more different sets of operators, each familiar with but one special stage of the process of cloth making. There are at least three persons doing in the aggregate what one did originally, each seeing but one-third of the process completed under his hands. But the total output will probably be much more than three times as large, even though the power loom weaves no faster than the hand loom or the spinning frame spins no faster than the hand wheel. This is because the time of changing from one sort of work to another is saved, and each operator becomes much more rapid and efficient by the constant contact with and repetition of his limited function. Whenever enough work is assembled in one establishment to allow this sort of segregation of functions, an economic gain is experienced. Thus, in a manufacturing machine-shop, instead of allowing the operative to perform one operation after another until he has finished a given article, we keep him, say upon one machine tool only — lathe, planer, drill press or whatever it may be — with the double object of saving, first, the time of changing from one part of the floor to another, and, second, of cultivating a higher degree of facility within the limited range. Next, we may go a step further, and instead of allowing our machinist to do all the miscellaneous work on a boring mill, for example, we keep him busy on boring nothing but one size of cylinder. We may even go further yet, and confine him to rough boring, moving the pieces afterwards to another specialist, who takes the finishing cut. If our production of standard sizes is large enough, we may keep him continuously at work rough boring only one size of cylinder. In certain lines of manufacture, for which America has become famous, this specialization has been pushed to remarkable extremes. In the making of shoes, for example, some operatives may spend a life time doing nothing but sewing a single seam in the uppers.

Standardization is the third great tendency in manufacturing, resulting from aggregation and going hand in hand with specialization. It is the reduction of work to fixed patterns, which are more and more controlled by the operations of the machine, so that skill of creation is more and more centred in a small force of designers and the ordinary workman becomes more and more a mere reproducer. It naturally follows specialization. If you give a man a single job or one stage of a job to do over and over, the logical and necessary thing is to give him at the same time a pattern or standard to which every repetition of his job shall exactly correspond. Take the case of making shoes. The old-fashioned journeyman shoemaker takes the lines of his customer's foot, builds up a last with patches here, and slices off parings there, models and measures and cuts and fits, and never makes two pairs of shoes exactly alike. The machine-made-shoe factory classifies all human feet into some dozen or two of stock sizes, reduces these to fixed patterns by which the leather is cut, sub-divides the sewing and other operations among an army of operators, each of whom does but one thing, few of whom ever see the finished shoe, and none of whom sees the foot that is to wear it; and among the standard sizes turned out (every pair of each size exactly like every other pair of that size) somewhere between 1 A and 13 EE, each member of the human race is supposed to find a shoe he or she can wear.

Standardization is reduction to type, and this reduction to type — this making everything of any given kind exactly like every other thing of that same kind — may be pushed to any degree of completeness. It may go so far that it comprehends the entire machine, as, for example, the locomotive, the dynamo, the typewriter, or the watch. Every part of any one of these machines may be made so exactly like the corresponding part of every other machine of the same kind, that perfect interchangeability is secured. This standard for the regular product has been set and substantially attained by many American manufacturers, notably in the lighter and finer mechanical lines such as the manufacture of firearms, sewing machines, cash registers, and watches. The parts going to make up any one of these mechanisms are made separately by different workmen, none of whom may see the complete device, or have any chance to fit the piece he is making to the other pieces with which it is to work. The part is turned out to standard pattern, perhaps on automatic and semi-automatic machines, controlled in its every dimension by limit gauges, and is made repetitively in dozens, hundreds, or thousands; yet when assembled with the scores or hundreds of other parts which go to make up the complete anatomy of the finished machine, it slides into its place and performs its appointed duty probably without needing even the touch of a file in the hands of the fitter.

In other cases where such absolute identity of reproduction is not possible, standardization may go part way. Perhaps one standard bed-plate may serve for several sizes of machines or engines. Sizes of shafting, or dimensions and tapers of bolts and other details or accessories, may often and advantageously be simplified by the adoption of one or a few standard types. Again, standardization may be applied to the operations by which a certain piece of work is performed, or the time in which it is to be done, the workman being provided with a schedule of instructions and being expected to follow them implicitly. The idea everywhere is to concentrate the thought and skill upon the production of the best possible type, and then to make the reduplication of that type a purely mechanical process. The production of the original type, whether this original is a machine or a method of working, involves very expensive study and the employment of very expensive talent. But the process of reduplication can generally be performed by very cheap labor; and this labor, through the constant repetition of a limited number of movements, often attains an almost incredible degree of rapidity. Under the old methods of hand manufacture, every unit of product was practically an original. It was built up piece by piece, almost wholly on the principle of " cut and fit and try again," and every good workman had to be a skilled artisan, to a greater or less extent a designer, often an artist, and an engineer. Under the modern method, the unusual and extraordinary skill of a small body of designers is made permanently effective in the tools and process, and the work of the journeyman is little more than mere muscular effort. Of course, this movement has characterized manufacturing everywhere to a greater or less extent; but in American practice it has been applied through a wider range and has been carried farther than it has abroad, not only in mechanical but also in structural engineering work.

" Mass Production " is a term often used to describe the method of wholesale manufacture resulting from specialization and standardization. It has to a great extent replaced the practice of building things singly to fill each individual order, just as the shoe factory has replaced the old-time cobbler. All sorts of things from carpet tacks up to machine tools, dynamos, steam engines, locomotives, even battleships, are manufactured in quantity, in standard patterns and sizes, and are placed upon the general market for each customer to pick out the pattern and size that meets his particular need. It is clear that in saving of cost of manufacture and in saving of time to the buyer the system offers great advantages, and that it also carries an advantage in that the interchangeability of parts characterizing standard apparatus greatly facilitates replacements and repairs. Three important commercial advantages, therefore, are inherent in the system; these are quality for price, promptness of delivery, and convenience of renewal or repair.

These great tendencies — aggregation, standardization and specialization — are all interlocked. It was only when a large number of operatives had been collected, working side by side on the same product, that it became possible as well as desirable to bring this product to a fixed pattern, so that they might all work alike. And it was only when this had been done that the parts of the work could be separated, that is, specialized, so that in a spectacle factory, for example, instead of every man making complete pairs of spectacles, one lot of men might do nothing but grind lenses, another group might do nothing but polish them, another group might cut them to shape, another group grind the edges, another group make the frames, and still another group fit the finished lenses into the finished frames.[1] The men in each group, working over and over at their limited job, can do it much faster and better than the original all-around man did. The complete process is thus cheapened, because each part of it has been cheapened; the product can be sold at a lower price and thus find larger markets; the increased demand at the lower price in turn makes it necessary to employ more men. The manufacturing organization thus proceeds to a larger growth; aggregation receives a new impetus; and so the cycle turns around again and again upon itself with increasing speed and force.

Although the immediate effect is industrial expansion at an increasing rate of increase, there are certain further results that are not favorable.

The first unfavorable result is the disappearance of the generally trained all-around skilled artisan. There is little opportunity under the present industrial system for a boy to learn a trade as every apprentice learned his trade in former years. Factory or shop conditions do not permit it, and the wage inducements are against it. A machine tender on a special job can acquire in a few months, or even weeks, enough skill in his limited routine to earn larger

[1] This is, of course, only an illustration. The making of spectacles is specialized to an immensely greater degree than this.

wages than the apprentice can hope to get in three years, and the ordinary beginner does not and perhaps can not look beyond this fact.

The second unfavorable effect is that although general standardization (that is, standardization of such things as weights and measures, screw threads, sizes of wire, sections of steel rails or structural shapes) is wholly desirable, private standardization (or standardization of each manufacturer's special product) leads to inflexibility and resistance to desirable change and improvement. Everything about the whole establishment — drawings, patterns, special machinery, processes, operations, materials — having once been standardized and installed for the standard product, can be changed and adapted to a different product only at considerable expense and trouble. It is a matter of common complaint that our American manufacturers very often oppose a tacit or even a stubborn resistance to advancement; that they buy up and pigeon-hole patents for improvements in their field; that they seek to control a market by masterful salesmanship, by combinations to regulate products and prices, rather than by progressive betterments of output. It is asserted by authorities of the highest credibility that we are losing, indeed have lost, our mechanical supremacy, largely through over-standardization, over-adherence to standard products — lost it to Continental manufacturers whose less complete standardization left them more elasticity, both of equipment and of mind, and enabled them to follow improvement after improvement, until in excellence of product, and especially in efficiency of product, they have left us far behind.

It would not be right to leave unmodified the impression that the disadvantages or the dangers just suggested are sufficient to overbalance or perhaps even to balance the benefits to industry and to the public which have come so far through standardization and specialization in manufacturing. The low cost of the product which has thus been secured has put it within the reach of large classes of buyers who would otherwise have been unable to purchase. The volume of manufactures, many of which in turn become the basis of other manufactures, has not only filled the world's stores with necessities, conveniences, luxuries, and tools of livelihood, but has made it possible to provide profitable occupation for the increase of the thronging nations who are filling up the once-abundant acres of the earth. Specialization, also, has furnished well-paid positions in vast numbers for a class of ability which could not have commanded skilled wages and which, if it were not for this opening, would have had to be content with the smaller pay of common labor. As against these great economic and social advantages, the drawbacks I referred to are perhaps small. Still, the dangers do exist, and they may increase if they are not recognized and met. It is part of the problem of the industrial engineer of the present and of the future to find preventive measures against the inflexibility — the ossification — which threatens us when we become over-standardized, and against the dreadful narrowing of functions and the deadly monotony of occupation which comes to us when our work is over-specialized.

We need, then, some countercheck that may be balanced against specialization and standardization, so that we may enjoy their economic advantages without incurring evils that lie beyond. This countercheck it is part of the industrial engineer's function to provide. The answer appears in the doctrines of that first apostle of scientific management, Frederick W. Taylor — in the gospels also according to Harrington Emerson and H. L. Gantt, and other leaders of advanced thought in this field. It is, in part, the exaltation of specialization — its investment with a new dignity, with depth in place of breadth, making *in*tensiveness instead of *ex*tensiveness, the goal of desirability; and with this, the recognition of a standard as something which itself must continually advance — as something which is a living evolution and not a rigid crystallization.

But we must not follow this thought further, as we have to consider another condition springing from aggregation as well as from specialization and standardization, and involving that most intensely interesting and important of all the problems of industrial engineering — the relation between employer and workman. This is the exchange of the workman's independent individuality for membership in a class. Under the old order the village blacksmith was a character, a landmark, a figure in local history and a theme in literature. Under the new order, the counterpart of this iron worker in a modern smithshop probably tends a forge press or works as one of the gang, and passes unnoticed to and from his work and into and out of his employer's service, filling a job designated by a number, and perhaps not even known by his own name.

And now we come to a very important point. When a plant employs thousands, and even a department employs hundreds, it is only by infrequent and improbable chance that a superintendent or manager can observe any individual difference among his many employees. Very rarely is any attempt made even to keep records by which individual performance can be studied and compared, if the supervising official should be anxious to make such comparison. The man of superior efficiency, even though he may do two or three times as well as the inferior workman beside him, has little chance of recognition and practically no chance of reward proportioned to his worth. His position is fixed, his wage is fixed, by his class and occupation. As Mr. Gantt has pointed out, it is inevitable that under such conditions the exertions of the more energetic man should be turned to the attempt to raise the class rate. It is inevitable that the efficient man should say: "I can't make any more money by laying more brick a day than Smith or Brown or Jones; but if I get Smith and Brown and Jones and all the boys to join in a demand for higher wages for bricklayers, we can get them."

A direct result of the submergence of the individual in a class is the elevation of the class into the attitude of an individual in its demand for recognition. But the class demands larger pay, not as the equivalent of larger work, but as a tribute to larger power. As a rule, the amount of work done by each man tends downward to the level of the least efficient; while the wages secured by the class through collective bargaining tend upward toward the maximum that can be grasped and held by the power of the union. This is immensely unsatisfactory to the employer, but it is the logical consequence of conditions that the employer — not the employee — has created.

One more great difficulty confronting the industrial engineer in the administration of the manufacturing system is the material counterpart of this impersonalizing of the man. It is the disindividualizing of the work, or, to use the more familiar language of the shop, of the job. As the practice of specialization already referred to divides all operations among different workmen and departments, the manufacture of any single thing, whether this thing is a locomotive or a watch or a bridge or a ton of copper or a pair of shoes or a train mile, starts in many different places by the apparently independent acts of many different men. Further, each of these separate acts, which is going to be co-ordinated with other acts so as to produce some completed article, each of these separate acts is not a sole individual act, but is one of a series of repeated identical acts performed by the workmen. I hope I make this point clear. Each unit of product is built up out of manifold elements gathered from the work of many men. The work of each man is divided and subdivided among many units of product. The lines of movement between the many workmen on the one hand, and the many units of product on the other hand, are an enormously complex interlacement. The industrial engineer must control the orderly guidance of this interlacement; he must see not only that the elementary producers do their work and do it efficiently, but that the elements thus produced are kept in the right balance and proportion and are combined to form the right product at the right place and at the right time. In every direction, then, the spaces, forces, institutions of industry have far outgrown the limits of the man. It seems as though the world of manufacturing were no longer one of persons, but of classes, departments, systems. And yet, in all human affairs the originating and guiding power is the individual brain. Nothing can take its place. However complex the order, it must rest upon a systematic support of human intelligences and wills. And the method of coordination by which many minds and hands carry on one of the vast industrial enterprises of the day is organization. Its fundamental principles and methods will be taken up in the following chapter.

PRINCIPLES OF INDUSTRIAL ORGANIZATION

CHAPTER III

PRINCIPLES OF INDUSTRIAL ORGANIZATION

WE have seen so far that the introduction of power and machinery first inaugurated the manufacturing era, and next gave rise to certain tendencies and policies in manufacturing. The most important of these were growth in size of the manufacturing plant, and development of manufacture on a wholesale scale; and in connection with this the re-apportionment of duties among the artisans employed, so that it has become general for each to do only some limited special part of the whole process of manufacture, and to do this by repetitive reproduction of a fixed pattern.

While this has vastly reduced costs of production and facilitated manufacture *per se,* it is evident that from the works-management point of view it introduces very serious problems. One is merely quantitative; the great size of a modern factory makes it impossible for the manager to oversee it all in person. Another is the division of operations among different workmen or departments. Each single thing manufactured starts, or may start, in as many different places as it has parts, each part again being not an individual but one of a lot of like parts; and such a lot of identical parts, though they start off together through the shop, may later on be divided and sub-divided and diverge to various finished products if they happen to be standard to more than one pattern. The workman actually engaged on the job has no idea of the destination of his work and no responsibility beyond finishing his own individual job to the standard pattern and quality, and perhaps within some standard time.

Take a pocket knife for illustration. It has a blade of a certain size and shape, which probably is used not only in the one pattern of knife we happen to be considering, but also in some two-bladed and some four-bladed knives made by the same factory. It has certain German silver pieces, probably drop-forged, possibly not made by the knife manufacturer at all, but bought in quantity from some other maker. It has some bone or pearl pieces, still more probably purchased from an outside manufacturer and used in a number of different styles of knife, sold at various prices. It has certain steel springs, and thin brass plates, and a number of rivets. All these parts in hundreds and thousands are passing through the factory, and being assembled into knives just like the one we happen to take as an example, and into other knives of more or less varying design, in a continuous stream year in and year out. Each individual workman, as, for example, the man grinding the blade, sees no more than his own job. But if the factory is to succeed, John Smith's order for one dozen knives like the one we have, to be shipped to Topeka, Kansas, must go forward at a specified time, and must be billed to him at a price that pays a fair profit, and still is low enough to meet competition from other knife factories.

The manufacture of a knife is a comparatively simple instance. In the case of some mechanical products such as typewriters and automobiles, for example, there are hundreds and thousands of separate pieces to be routed through the factory, worked upon, and finally assembled into a unit of product. The paths of the several parts are something like the paths of letters in the mail; a myriad of units from scattered sources are gathered into larger streams, travel together so long as their paths can be economically united, and then diverge again in new groupings to various individual destinations. It is utterly impossible for any one person to follow each transaction, and yet a positive and sure result must be secured. And this is the function of organization. System must do what the individual can not accomplish.

It looks like an impossibly intricate problem; and yet if we look again at the illustration used just above — the Post-Office — we see that a fixed organization and fixed systems of collection, transportation, and distribution produce a result in exact accordance with our plan and desire, and with almost infinite variety and elasticity in meeting that plan and desire. This is an illustration only — not a close parallel; for in manufacturing we have the added condition that each item handled is or may be worked upon and changed during its movement through the factory, and in all industry all operations and processes must be conducted with strict regard to economy and efficiency. We have not an unlimited Government appropriation behind us, and we have the neighbor across the way competing with us and by close bidding forcing prices down so that we have to consider even small fractions of a cent. Still, the illustration helps us to see what organization and system do accomplish.

Organization is fundamentally a practical plan for subdividing the conduct of any undertaking into parts, each small enough to be handled by an individual, by a method that enables all to work together. The efficiency of organization depends on the wisdom and skill with which this division is made — the success secured not only in selecting efficient individuals, but in arranging that each may work at his best efficiency, and all work may keep balance and harmony in achieving the desired result.

There are two great principles in organization commonly known as line and staff, or, to use the terms preferred by some industrial engineers, "military" [1] and "functional."

[1] The use of the term "military" in this sense is misleading. Military organization has long comprehended both line and staff. Indeed, as the

Line organization is essentially simple, mathematical subdivision. An army under a major-general is divided into brigades under brigadier-generals; each brigade is divided into regiments, under their colonels, and each regiment into battalions under lieutenant-colonels or majors; each battalion is divided into companies under captains; each company is again subdivided under its lieutenants, and so on down to the corporal with his squad. Promotion is step by step upward; the private may hope to be made a corporal, a sergeant, a lieutenant, a captain, a major, a colonel, a general. The lines of authority and responsibility run continuously through the whole body from top to bottom, as the veins of the leaf gather to the stalk, and many leaf-stalks to the twig, and many twigs to the branch, and many branches to the trunk; and veins and stalk and twig and branch and trunk have practically similar duties to perform in the life and growth of the tree.

Staff organization is a division according to functions — division by which one military department does all the engineering work for the whole army, another supplies all clothing, or rations, etc. It is the division by which the roots absorb moisture and salts from the earth, the leaf cells make chlorophyll, the sap carries the products of these laboratories to the cell-building processes of the tree. Staff functions are co-ordinate and co-operative, but they do not stand to one another in any order of ascending and descending scale. The captain, simply as captain, ranks and commands the lieutenant; that is a line relation. But the engineer, as engineer, does not command the quarter-master; the quarter-master does not rank and command the surgeon; the leaf does not rank the root; that is a staff relation. On the other hand, the captain is primarily responsible only

oldest of the "noble professions," the military long since discovered and applied many of the principles lately reannounced by investigators of "scientific management."

for his own company; each branch of the tree supports only its own twigs and each twig its own leaves. That, again, is line organization. The scope of the individual is limited in area, but unlimited in responsibility within that area. But the engineer builds a bridge for the entire army — general, colonels, captains, and privates; each root and leaf contributes its share to the life of the entire tree. That is staff organization. The responsibility of the individual is unlimited in area, but limited to one function throughout that area.

The functions of staff and line are, therefore, not antagonistic; they are not alternative and rival systems of organization, between which we may choose and say we will adopt this or that and refuse the other. Line organization is essential to discipline and essential to the continuous existence of the whole body. If the general retires there must be a colonel to succeed him; if the captain is killed in action, the lieutenant must take command of the company, or the men are scattered and lost. Staff organization is essential to efficiency, each branch of it in its own particular function. If the commissary fails and there is no food for the troops, the engineer can not make up for the deficiency by vigorously building bridges. Each staff must have a line organization within itself for discipline and continuity; but every complete organization must embody the principles of both line and staff if we are to secure the best results, the staff supplying expert functional guidance, applied through the line's direct control.

In manufacturing and industrial operations generally there is no lack of development of line organization, but there is too often a very meagre appreciation of the valuable results attainable by far-reaching applications of the staff principle. This is generally characteristic of modern industrial concerns, and it is here that we are likely to discover weakness when the attainment of high efficiency is desired. Under line organization, the foreman is supposed to decide every question for the men under his particular control — employment or discharge, wages, jobs, difficulties with materials, difficulties with tools, difficulties with processes, difficulties with other employees. If the question is too big for the foreman he goes to the superintendent, and if it is too much for the superintendent he puts it to the general manager, and it may finally go to the board of directors. The assumption under-lying is akin to the supposition that the corporal must be a better shot than the private, and the sergeant than the corporal, and the lieutenant than the sergeant, and so on up to the general in command. It is one of the very strong features of what has lately been called "scientific management," that in its study of operations, its preparation of instructions, and its formulation of schedules, it introduces staff co-operation to a yet larger extent through the work of expert instructors. We need a much fuller recognition of this principle, not as the occasional or unusual accompaniment of the introduction of a new system, but as an organic part of our regular system. We need to incorporate the staff idea into our settled industrial policy, so that expert direction as to relations with employees, as to equipment and its maintenance, as to materials, as to methods and conditions, as to performance, shall operate throughout our works not in series but in parallel, and shall be available at every point, to every man, in every job, at every time.

The average foreman is not — could not be — able for all this. He is rarely strong in even one of the three parts into which Mr. Gantt divides the labor problem — finding out what is the proper day's task for a man suited to the work, finding out what is the compensation needed to induce the man to do that work, and planning so that the man can do the work continuously and efficiently. These are the things that control the result of all our industrial ventures. After we have laid our plans and bought and installed our machines and assembled our forces and organized our whole complicated establishment, with its investment of money and hopes and expectations, the result depends very largely on the efficiency of the individual workman. The cultivation of high efficiency is a matter of vast importance not merely to the invested capital, but to the economic and social future of the country. It has been left in the past very largely to the foreman, and because he did not know and could not know the conditions that produce inefficiency, and the means of cultivating efficiency, the output of the average worker (in the estimate of very careful students of the question) is not one-third of what it should be and can be without any increased tax on the body or brain of the operative. Here is an opportunity for the conservation of human resources which comes nearer home even than the conservation of coal or of water powers.

The defect of the average, usual, old-line organization is that, in the desperate speed of industrial expansion, it has tried to meet the onslaught of conditions, the mere quantitative problem of expansion, by throwing itself into the only form with which humanity (as the heritage of centuries of fighting) is intimately familiar — the military form. The ordinary philosophy of management is (to borrow a definition from Harrington Emerson) " autocratic authority at the top — delegated authority and imposed responsibility all down the line, and anarchy everywhere." Just as in emergencies each man below turns to the man above, so in ordinary routine the order is reversed. The president " puts it up " to the general manager, the general manager "puts it up " to the superintendent, the superintendent " puts it up " to the foreman, the foreman " puts it up " to the workman. The work is finally done by, and the efficiency of actual execution is usually dependent upon, the man of lowest capacity, of least knowledge, of least possible breadth of vision, of least power to control conditions — that is, the actual workman. His only source of all help and instruction is usually but one step higher in knowledge or in power, and that is a job boss or foreman.

The entire ideal of industrial-engineering organization, of "scientific management," as it has lately been called, is diametrically different. It is the study of the plans for executing the work and of the ultimate operations of the work itself by the highest expert skill obtainable; the definition of the best means for doing the work by the most competent specialist obtainable; the reduction of these results to standard definitions and standard instructions; the provision of the best apparatus for doing the work, and its maintenance in the best condition, again by specialized skill; the careful training of the workmen by competent instructors to do the job in the best way with these best appliances, and in the minimum of time; lastly, the provision of some incentive sufficient to secure the workman's co-operation, to make him willing to do the work in the way and in the time that have been studied out. This incentive may be a day wage, a piece rate, a differential piece rate, a bonus, a premium, or a purely sentimental reward —"an imaginary value," as Dr. Junge calls it. These wage methods are not fundamental institutions in themselves, as they are sometimes mistakenly supposed to be. They are, or should be, only the last step in a far broader philosophy of production. Scientific management, then, involves these three great steps: First, analysis — or the accurate estimation of productive elements and preventable wastes; second, standardization of attainable maxima of performance, and establishment of conditions by which the men may practically reach these maxima; third, and last, devising an incentive by which the interest of the employee is visibly and convincingly advanced, parallel with the interest of the employer, as the workman approaches and reaches or even surpasses the standards set.

To sum up in three words: The elements of scientific management are analysis, standardization, incentive.

The difference between it and ordinary management is that it provides for these things, while ordinary management provides only for the transmission of orders and maintenance of discipline, with little or no instruction or assistance to the workers.

To put it in still another way: by co-ordinating the two elementary ideals of management — line, for permanence, authority, discipline; staff, for development of high functional efficiency —" scientific management "[1] restores, both to the job and the man, the identity — the individualism — which under ordinary management is lost by a policy of wholesale dealings and mass relations.

At the present time two leading schools of scientific management seem to be forming, characteristically associated with the names of F. W. Taylor and Harrington Emerson. It is hardly fair to the subject or to the reader to attempt to point out in a brief paragraph their distinctive doctrines, for each requires and has been given by its chief sponsor an exposition reaching the dimensions of a fair sized book.[2] As an introduction or an incentive to further study, however, the following summary is offered:

The Taylor system displaces ordinary management by the introduction of a highly specific, distinctly defined

[1] The term "scientific management" is used with some reluctance because of its general current employment in a restricted and specialized sense. Scientific management means only the application of scientific principles and methods to the work of management. The sciences involved may be, and are, several. Scientific management can not be reduced to a formalized and formulated system, although a systematic scheme of management may be based on scientific principles.

[2] See "Shop Management," by F. W. Taylor; Trans. Am. Soc. M. E. June, 1903. No. 1003. See also "Efficiency as a Basis for Operation and Wages," Harrington Emerson; *The Engineering Magazine.*

"functional force." The performance of work is first divided into two phases — planning and execution. Each of these phases is separated into four major functions. The four functional representatives in the planning department are "the order of work clerk," "the instruction card man," "the time and cost clerk," and "the shop disciplinarian." The four functional representatives in the active work of the shop are "the gang boss," "the speed boss," "the inspector," and "the repair boss." There may be one or many representatives of each function, depending upon the frequency with which their function necessarily brings them in contact with the men; but within any one function, the workman looks to the particular boss of that function for his orders and assistance. The workman takes orders from eight different bosses instead of from one only as under the ordinary system of management. The details of the system are also highly specific, as, for example, that all work, tools, and equipment parts are symbolized, the performance of every operation is charted, all instructions are written, etc. The salient feature, however, is that the old line organization is discarded, and eight functional lines are put in its place.

Emerson leaves the old line intact, but supplements it with an expert staff, who bring to bear highly specialized knowledge and skill upon the various elements of operation that are susceptible to improvement. These might be, for example, such matters as the economical burning of fuel, the custody and issue of materials, the cutting of metals, the care of machinery and equipment; these are random illustrations only. The staff organization would be specialists in the subjects of largest influence upon economy of operation, but their knowledge would be applied, not by direct orders to the workmen, but by guidance, instruction, suggestion, counsel, to the regular line officials. Emerson's faith is not in methods, but in principles of efficiency and their pursuit by a line-directed and staff-guided organization, adapted to the circumstances and conditions of any given operation. These principles of efficiency are: Ideals; Common-Sense and Judgment; Competent Counsel; Discipline; the Fair Deal; Reliable, Immediate and Accurate Records; Planning and Dispatching; Standards and Schedules; Standardized Conditions; Standardized Operations; Written Standard-Practice Instructions; and Efficiency Reward.[1]

In the acceptance of fundamental ideas and foundational data there is no important difference between the two schools. In methods of practice there is a very wide difference, the latter being much the more elastic. One of the first precepts of the Taylor school is that no half-measures are possible. The system must be adopted in its entirety or let entirely alone. From Emerson's doctrine of efficiency, on the other hand, follows the deduction that betterment may proceed by almost infinite gradations, depending on the willingness and thoroughness with which the principles of efficiency are accepted and applied.

In the early sections of this chapter organization and system were spoken of as being effective in controlling large operations that are beyond the grasp of the individual. System is the method by which organization works to secure desired results and to maintain control of every item of work in hand at all times. If, ignoring the conventional mode of analyzing industrial organization, we look at it from the point of view taken in the alliterative divisions of the field listed in the opening chapter, the applications of system in which we are most interested in industrial engineering will relate generally to six cardinal points. First, the general institutions and form of management; second, the provision and custody of material; third, the handling and payment of labor or " men "; fourth, the care

[1] " The Twelve Principles of Efficiency;" *The Engineering Magazine*. June, 1910, *et seq.*

and maintenance of tools and machinery; fifth, the determination and direction of operations, or manufacturing methods; sixth, the recording of expenditures and costs — that is, of money. Our seventh " M "— markets — belong to the commercial or sales organization, and though equally susceptible to scientific treatment are not included in the scope of this study.

System is an ideal that is more or less perfectly embodied in innumerable concrete " systems " for handling each and all of these things. There is no universally correct and specific way of doing any one of them. Always beware of the man with the panacea. Ideals and principles are fundamental and fixed; methods and systems must vary with conditions. The systems that will succeed in any given case depend on the organization adopted in, and the circumstances surrounding, that case. Many misfits and troubles have resulted from attempts to force cut-and-dried systems that had succeeded under one set of conditions and in one environment, upon a plant differently organized and environed to which these systems were not adapted at all. There are, nevertheless, fixed principles that can be formulated and should be observed in any system we may adopt in any individual case.

Management, in its broad sense, includes everything in the entire range of this discussion. In its limited sense of the governing and directing body it is ordinarily (as already said) dominated too exclusively by ideals of " line " subdivision with insufficient " staff " co-ordination. Very generally, however, a broad staff or functional segregation appears in the adoption of what is called the " three-column form " of organization; that is, the management is carried on by three co-ordinated departments — financial, manufacturing, and commercial. The division is elementary and logical. First get your money, next turn it into manufactured wares, then sell the product. Below this step, however, ordinary management is unstandardized. All effective work in the improvement of efficiency must begin here, either by replacing the existing arrangement by a "functional force" or by "co-ordinating with it in an expert staff."

Materials are generally supplied through a purchasing department, whose duty it is to provide all materials and supplies in the quantity and quality required by the production department, at the most advantageous price possible; and to verify its purchases to the auditing department for payment. Materials when received pass into the custody of the stores department, at the head of which is an official known as the storeskeeper or storekeeper. In a large plant there will probably be a general storeskeeper and a sufficient number of division or assistant storeskeepers and clerks to handle the work. The duty of the stores department is to keep materials in safe custody and orderly arrangement, to supply them to the departments of the factory on requisitions from proper authority, to account for their issue, to receive them again, in partly finished or finished condition, if the routine of the factory operation so requires, and to maintain an inventory of all material on hand. Sometimes finished product is delivered from stores on order of the sales department; sometimes the shipping department is distinct. Obviously both purchasing department and stores department must be in close touch with the needs of the production department, but the discretion given either of them to query or to anticipate production-department requisitions or wants varies greatly in different cases, and may be determined by the policy of the concern or the personality of the officials chiefly concerned. It is not uncommon, however, for the stores department to be charged with responsibility for maintaining at all times a sufficient stock not only of raw materials but of finished product. The manufacturing department then works always and only upon orders issued by the stores department.

The records of materials are usually kept by requisitions made out in multiple, separate copies going to the manufacturing and accounting officials immediately concerned, and by entering each addition or withdrawal in books or on cards accompanying each lot or kind of material carried in stock. The movement of material through the factory is usually directed and recorded by tags, accompanying each piece or lot, and distinguished by serial numbers connecting them with the order or job to which they apply. Multiple copies of these memoranda, sent ahead, serve to notify responsible officials further down the line what to look for, and act as detectors for any delay or discrepancy in arrival. This system is commonly called stock tracing.

Material in process of manufacture is commonly called either stock or stores. The terms are rather loosely used, but the best authority prescribes the use of the term " stores " for raw material and " stock " for finished product. This usage, however, is not universal, and very often " rough stores " or " raw stores " is used to designate unmanufactured material, and " finished stores," manufactured material.

Labor, which was listed as the third cardinal subject of systematic handling, is very diversely managed. Some large concerns have a regular labor department or employment agency where applications are filed and examined, and by which men are engaged in such numbers and at such times as the managing officials direct. In other cases the heads of departments make their own engagements and discharges. Usually the discipline and work assignments of each employee depend upon his immediate superior, who may be a very minor official, such as a gang boss or subforeman. Many disciplinarians consider that the power of promotion or discharge is necessary to the man in immediate command. There are, however, great dangers of injustice, and of the exercise of favoritism or spite disastrous to efficiency of the working force as a whole, if too much power is entrusted to petty officers. I think this is on the whole the safer view to adopt. The assignment of work, even, when not determined by general routine, is now sometimes advantageously directed from a central works office, where a work dispatcher has every machine in the shop displayed before him on a board, with its jobs in hand or accumulated systematically tabulated on slips, and he directs the next movement for each man and machine on the floor, as a train dispatcher moves the trains on a railroad.

The individual jobs are usually designated by numbers connecting them with the work to which they apply. The time each man works is usually recorded by a representative of the accounting or auditing or cost department, called a time clerk or a timekeeper. Very generally each workman registers his entrance and departure by punching a time clock or some similar automatic recording device, so that the total time for which he is paid is indisputable. The division of his time among various jobs (if his work is of such character that it is divided among several jobs) is noted either by himself, by his foreman, or by the time clerk, who then makes frequent rounds of the shop and visits every man often enough to keep close track. These time records, like the material records, are usually kept on individual cards, which can be assembled afterwards for such tabulations and cost determinations as are desired and may be kept as long as deemed advisable for further reference. The system of payment is determined by the management in the light of such appreciation as the managers may have of the virtue and benefits of the several advanced wage systems, and under such limitations as the prejudices of the men or the effective restriction of the union may require.

The fourth cardinal point listed for systematic direction was the care and maintenance of tools and machinery. The larger mechanical equipment, power transmission, etc., is too often left more or less vaguely to the engineering or mechanical department, from whom it devolves upon the foremen. There is, however, a generally recognized and almost universally established institution called the tool room, which has two separate functions; one is the custody and issue of small tools, which are provided, ground, kept in order, and given out to the men as needed, account being kept by hanging a brass check representing the tool on a hook bearing the workman's number. The other and larger function of the tool room is the making of standard and special tools, jigs, fixtures, etc., and the repair of machines and machinery. The province of the tool room, however, is seldom extended widely enough and the toolmaker's knowledge of the most efficient operation of machines and of the principal causes of waste and loss of time is seldom deep enough, or his authority to institute reforms and is seldom great enough, to make the tool room adequate to drive the plant at its highest capacity. Here is an opportunity for most profitable use of the staff specialist.

The direction of methods, our fifth cardinal point, is in a still more unsatisfactory condition. It is left sometimes to the men running the machines, sometimes to their foreman or to a special functional foreman, sometimes to the tool room, sometimes to the drafting room, and sometimes to the engineering department or mechanical department at large. Here is another broad field for the staff specialist.

Systematic supervision of money matters, our sixth cardinal point in manufacturing organization, exists in two directions. Both are based, in part at least, on the same data, but their scope and purpose are quite diverse. The first of these functions is exercised by the auditor's department. Its purpose is simply to connect every expenditure with an actual *bona fide* transaction — material bought and vouched for, wages paid for services proved, royalties paid on a verified contract, machines purchased, buildings erected, etc. Time and material tickets coming from the shop are merely vouchers to the auditor, to warrant his O. K. of requisitions on the treasurer for the payment of bills or the drawing of payroll checks. Beyond this, he is not in the least concerned officially. If John Smith is certified on the payroll for 60 hours, as proved by the time clock, and at 25 cents an hour as certified by his general foreman, the auditor approves his payroll check for $15 without further question.

But the second department concerned in money matters has a different function; this is the cost department. The time and material cards, having served as auditor's vouchers if necessary, are taken in hand by the cost department and sorted by numbers so that all cards belonging to any particular job, machine, or desired item of product fall together. From these the complete material and labor cost of any piece or product (or by proper prearrangement, of any part of a unit of product or of any operation upon any part) can be figured up and recorded. It is part of the function of the cost department not merely to connect expenditures with certain manufacturing accounts as the auditor does, but to determine by comparison whether the expenditure and the thing secured by it are in fair proportion. The auditor went no farther than to find that John Smith put in 60 hours by the clock. The cost department divides up this 60 hours, job by job, and it can or should compare John Smith's time on each job with recorded times made by other men on the same jobs. If he has been soldiering and has done altogether in 60 hours only what the records show that other men have previously done in 25 hours, the facts are made clear and proper action can be taken.

The cost department, properly conducted, may thus become a mine of valuable information, first for the shop superintendent in helping him to prove the comparative worth of his men, and next for the commercial or sales organization, because it shows not only what margin of profit exists and affords a guide to possibilities of meeting competition, but it also permits close estimates to be made on new work, by a comparison with similar jobs in the past and by compiling unit prices from which the costs of new models may be built up.

FORMS OF INDUSTRIAL OWNERSHIP

CHAPTER IV

FORMS OF INDUSTRIAL OWNERSHIP

PURSUIT of a systematic inquiry into the science, principles and institutions by which manufacturing operations are carried on leads from the general to the specific. It is therefore proper to supplement the examination of organization at large by a short survey of the forms of organization legally established for the conduct of industrial operations. These are few and highly specific. For while the internal regulation of industrial concerns, being governed by individual freedom, is (as we have seen) far from standardization, their external relations have been very exactly fixed by law. Society, in its general care for the rights of the individual and of property, has prescribed certain definite forms of ownership by which the manufacturing plant may be held and operated.

The first and simplest of course is possession and operation by the individual owner. It is scarcely necessary to comment upon so familiar an institution as single proprietorship. The condition is one that has probably come under the personal observation and experience of all of us, and if we magnify the cobbler's bench up to the huge shoe factory, or the little jobbing foundry up to the gigantic iron works, the legal position of the individual proprietor is substantially unchanged. He may hire such assistance as he desires, delegate to employees such of his powers or functions as he sees fit, carry on the most diverse occupations if he think best. His credit is such as he may establish by his character and property qualifications. His liability extends to all that he has, subject only to the ordinary legal exemptions, to which all men are entitled. In short, he has all the authority, all the profits, and all the responsibility, and he carries on business as he sees fit, subject only to the general law of the land.

One qualification of the individual freedom to carry on an individual proprietorship without public notice or legal restraint should, however, be noted. If a man elects to operate not under his own name, but under such style as the Elite Foundry or the Vacuum Process Co. or the Excelsior Machine Shop, although in fact he is sole owner and proprietor, he must file in a designated public office (in New York State, the office of the county clerk) a statement setting forth who is actually carrying on the business and all necessary information to advise the public duly of the facts and the person responsible for the acts, obligations and debts of the business.

There is no necessary limit to the size of the business that may be conducted individually. The Krupp works were so carried to a foremost position in the iron and steel industry of the world; and I believe they are yet (or at least they were quite recently) under individual sole ownership, though the actual management had been turned over largely to a *Direktorium* of twelve members.

For reasons of convenience or finance, however, it often becomes expedient for an owner to divide his duties, profits and responsibilities with one or several others, who become joint owners with him, in equal or unequal proportion as the special arrangements may determine. In the case of a new business several men may thus associate themselves in joint ownership at the outset, each contributing his share of money and his particular talents and work to the prosecution of the business. In the case of a business which has been running as a sole proprietorship, the original owner may want to attach an important employee permanently to the business by giving him a share in the results, rather than a mere salary independent of the results. He may want to bring in more capital without borrowing against his own credit. Or he may want to bring in some special knowledge or skill or some trade connection possessed by some special individual. In either case, or for whatever motive, we have as the result a second form of industrial unit, no longer single, but compound; this is the partnership or joint partnership or firm, as it is variously called.

A partnership is a group of individuals (usually a small group) who have joined their property, services, and credit, for the purposes of conducting business for their joint benefit. This relation is established by agreement between themselves, but it is subject to certain regulations or limitations or definitions, both under the old common law and by statute. These statutory provisions concern both the relations of individual partners to one another, and relations of the entire partnership to outside individuals or to the public at large. You can readily see how the creation and use of the partnership as an industrial institution would necessarily give rise to a body of partnership law. Smith, Jones and Robinson, doing business as a partnership, owning certain property, machinery and materials in the firm name, making a contract with you to employ your services as superintendent, or to buy from you a steam engine which you are to build on their order, are, plainly enough, a distinct entity, separate and different from either Smith, or Jones, or Robinson individually. If John Smith individually contracts with you to do or supply some thing, you know that you are to look to him personally for performance of that contract and that he can be held financially responsible to the extent of his entire property for faithful performance. But suppose Smith, as a member of the firm Smith, Jones and Robinson, makes a similar contract; has he divested himself of two-thirds of his responsibility by taking in these two partners? Or if the contract is not carried out and it proves that Smith, after all, has no property from which you can recover damages for the non-performance, can you take Jones's house or Robinson's bank deposit to make you whole in a negotiation which was originally begun with Smith?

These and other questions of the rights and duties of joint partnership are settled by rules of law or by statutes which vary somewhat in different countries and states. In general, however, a partnership, and each and every partner in that partnership, is bound by the act of any member of the partnership done in the name of the firm and within the scope of his apparent authority. In other words, each partner is a general agent of the firm, with full authority to do any and every act necessary to the transaction of the firm's business. Each partner, also, is liable for all contract obligations of the firm, whether incurred by himself or some other partner, and each partner is liable for wrongful acts committed by one or more of his fellow partners within the scope of their apparent authority.

For instance, suppose Smith, Jones and Robinson are a firm of iron founders, and Smith, driving a truck load of castings for delivery to a customer, negligently runs over a pedestrian in the street and injures him, or negligently runs into another wagon and overturns it, giving rise to damages. The firm will be liable for these damages, and if the firm's property were insufficient to pay the amount awarded, Jones's personal property or Robinson's might be attached to pay the judgment for the act done by Smith. This is an instance of a wrongful act committed within the scope of Smith's apparent authority as a member of the firm. If he got down from his truck and beat a man on the sidewalk, the firm as a firm or the other persons individually would not be liable, because the act, although wrongful enough, is not within the scope of his apparent authority.

To a certain extent, therefore, the law makes a partnership an artificial person. In the case of liability for accidents the firm's property must be exhausted before the personal property of its component members is taken. But when the limit of the firm's property is reached, the persons are each accountable for debts and acts of the firm as if these debts and acts were their own personally.

There is, however, an exception to be noted in the case of special partnerships. A man may enter a firm as special partner to the extent of a fixed amount of capital and with the limitation of his liability to this amount of capital actually contributed; but this is permitted by statute only on condition that the special partner's stated contribution is actually all paid in cash; and furthermore in such cases a certificate must be duly filed with the proper public official setting forth who are the general and who are the special partners, with the amounts contributed by each of the special partners, and an affidavit that these amounts have actually been fully paid in. They must also advertise in the county in which their chief place of business is located, specifying the general and special partners and the amounts contributed by each, and giving a copy of the affidavit and the articles of agreement. Furthermore, no firm can be composed of special partners only. There must be at least one general partner whose liability is unlimited.

To the largest possible extent, however, the law leaves a partnership as free as an individual in the transaction of business, with no restrictions as to the number and kinds of legitimate business a single partnership may carry on. This, as we shall see, is in contradistinction to the last form of business organization we are to consider, the corporation or stock company, which is altogether an artificial person, operating with such powers only, with such scope only, and under such conditions only, as are expressly stipulated by the statutes permitting it to exist.

Before taking up the corporation, there is one other but relatively unimportant form of business organization to be noted.

A joint-stock association is formed by agreement among its members, requiring no charter and no publication of the articles. The capital is divided into shares, as in a corporation, and the shares are freely transferable. It may sue and be sued by its president and treasurer, and its directors are personally liable for its obligations after the property of the association is exhausted. It exists by recognition of statute.

A corporation is a wholly artificial person. It is recognized by law and created in accordance with the legal regulation for carrying on undertakings of various kinds, public or private, eleemosynary or commercial, financial or transportation. We are concerned only with commercial or industrial corporations. As the corporation exists by provision of law, it has only such powers, rights, and privileges as are expressly conferred by law. It has not the natural and inherent rights possessed by an individual. This is one of the principal distinctions between the position and conduct of the corporation and that of an individual proprietorship or firm. Smith, Jones and Robinson may start up in business as a firm without notice to anybody, if they so please, and do any and every kind of lawful business they may elect to carry on. Excepting in the particular case of a special partnership already referred to, no declaration of their agreement, nor of their money matters, is required nor need they declare their respective functions in the business. They may think it expedient to make a statement of their finances or of other details to their bankers, or to those from whom they wish to buy on credit, but it is a voluntary and private communication. If, however, they decide to incorporate as the Smith, Jones and Robinson Co. they must file articles of incorporation with the secretary of State and with the county clerk in the county where their principal office is situated, declaring their purpose, defining the kind of business they propose to carry on, and the amount of capital with which they propose to operate. They must secure from the secretary of State a charter authorizing them to carry on business; and while the charters of large corporations especially are often very broad, a corporation is not in general permitted to do any kind of business not fairly included in the charter provisions; for example a company incorporated for manufacturing may not generally engage in banking, nor may a railroad company engage in mining.

The case of the "Coal Roads" illustrative of this point is fresh in mind. The charter of the U. S. Steel Corporation is very broad, but very probably it could not legally engage in the theatrical business in Pittsburg. Corporations must state in their articles of incorporation the capital (that is, the amount of money value) which they profess to devote to the purposes of their business, and they must pay an incorporation tax and a tax annually thereafter on this capitalization. This capital, however, is often nominal, and there is no general legal requirement nor provision for public inquiry into the equivalence of the capital declared and the value of the property and funds actually possessed by the corporation, although New York State subscriptions to capital stock must be paid in cash or in property at a fair valuation. That is a matter in which the investor who is putting funds into the corporation must determine for himself. The market value of the stock of any going corporation usually expresses the public estimate of its actual worth. There is, however, a tendency of late (as part of the movement to exercise larger governmental control of corporations) to provide for some official physical valuation, especially of the property of railroad corporations, with a view to larger protection of investors against the deceptions of promoters or of manipulators.

In financial make-up the firm and the corporation differ thus: The proportions in which the members of a firm share in the ownership and the results of business are fixed by agreement among themselves. As a general proposition, no new member may be admitted to a firm, no member may retire, no member may transfer to another person all or any part of his interest, without the consent of all the other members of the firm or without adjustment of the debits or credits of the firm to date of change. In a corporation the total capitalization is divided into a fixed number of shares. Each of these shares has a definite par value — usually $100, though some large industrial companies have shares of a par value of $50 and many mining corporations divide their stock into shares of a par value of $10, $5 or even $1.

These shares are commonly sold in the first instance by public subscription or given in exchange for properties, patents, etc., and thereafter are transferable without restriction, passing from hand to hand in the open market, purchasable by anybody in any quantity that market conditions permit. In the case of the large corporations listed on the exchanges, the stock is traded in to the extent of thousands, tens of thousands, and even hundreds of thousands of shares a day. Each transfer is recorded if desired by the buyer on the books of the corporation. The buyer brings in the old certificate endorsed by the former owner, with proper witnessing signatures, and receives in exchange a new certificate issued in his own name. The corporation recognizes as voting members those stockholders whose names are registered on its stock ledgers at any given time, and the voting power of each shareholder is measured by his stock holdings. Thus the membership in a corporation may be and usually is constantly shifting, both as to persons and proportion held by each.

There is another very important financial difference between a corporation and a firm. In a firm, as we have already seen, each member (except a special member) is like an individual proprietor in that he is liable to the extent of his entire possessions for the liabilities of the firm. Now a stockholder in a corporation is not usually liable, either for its debts or its wrongful acts, beyond the amount of his stock. That stock may become valueless because all the property of the corporation is exhausted, and so the stockholder may lose what he has put in; but the creditors or the holders of a judgment against a corporation can not go beyond the property of that corporation and attach property of the individual stockholder. In former times, under the old law of corporations, a creditor could do so, and in one famous case in Scotland, the case of a bank, if I remember rightly, every stockholder, no matter how small his holding, was ruined by the failure of the bank, the successive assessments to meet the debts of the corporation exhausting finally the last shilling of the last man. In some places and in some kinds of corporations there still exists what is called "double liability." That is, each stockholder may not only lose originally what he put in, but he may be compelled to pay in addition an amount equal to the par value of his stock holdings if this is necessary to meet the obligations of the company. This is the case with all national banks, but with manufacturing corporations it is exceptional and as a general proposition there is no liability and no assessment collectible beyond the single value of the stock each member of the corporation holds.

The management of a corporation is vested in a board of directors elected annually by the stockholders. These directors in turn elect the officers of the company and appoint its chief officials. The law requires that there shall be certain specified officers, in New York a president, a secretary, and a treasurer. Other officers may be added if desired. Very frequently in large corporations there are several vice-presidents, each heading one of the principal divisions of the corporation's work. One, for example, may be a financial man and look after marketing of bonds or notes, loans, and banking and financial affairs generally; another may direct the commercial or sales department; a third may be a technical man in charge of manufacturing or production; a fourth may be a lawyer and control the legal work, the drawing of contracts, patents, etc. The general manager, who is the active executive official in direct charge of the principal activities of the corporation, is very often, perhaps generally, not a director, although in many cases the president or vice-president is also general manager.

Directors are elected for a term of one year by a majority vote of all the stock represented at the meeting. A single share may thus determine the control of a large corporation. In our larger and better companies, however, it is generally conceded as a moral right that a large unified minority interest shall have representation on the board of directors. If "cumulative voting" is provided for in the constitution of the company, a respectable minority may become actually able to elect a director, irrespective of any moral right to representation. The amount of freedom given to individual officers or officials (freedom, that is, to act without prior approval by the directors) naturally varies greatly with the circumstances. Very generally, an executive committee of limited membership, easily got together for consultation by the general manager, has plenary powers and decides even very important matters without calling together the full board, merely reporting its action for confirmation at a later regular meeting. But in an issue, the majority vote of the board of directors decides. You often see, therefore, a struggle for control of a large company thrown into the stock market, both sides striving to buy up floating stock so as to control votes in the election of a board of directors who will carry out their policies.

There is an old saying that a corporation never dies. Even a corporation may be extinguished under proper legal procedure by settling all its obligations, dividing its assets pro rata, and surrendering its charter. But a corporation is not affected as to continuity by the death of any individual. It is immaterial to its mere existence who owns any part of its stock. An individual proprietorship or firm, on the other hand, may be very seriously embarrassed and even unwillingly forced to wind up by the death of a sole owner in one case or of a partner in the other. Some difficulty or embarrassment in administering the estate of the deceased, some quarrel among the heirs — if no one interest is strong enough to buy out all the others, may leave no alternative except to close out the business. But as the corporation is an artificial entity, wholly independent of any of its component members, it goes on unaffected.

For this reason, as well as on account of the limitation of liability already spoken of, a corporation is strongly favored even for businesses which are essentially proprietary. A man may make a stock company of his own business, distributing just enough shares to secure the legal number of stockholders, and electing officers from members of his own family or entirely trustworthy friends, and thus may give his business a form in which it may be perpetuated without danger of immediate collapse at his death. For this and other reasons industrial undertakings in the United States tend more and more to be conducted under the form of an incorporated company.

The money paid in by the stockholders when the company is first organized is its capital stock or capital. This is used to provide (or, as already noted, it may in part already have the form of) buildings, machinery, patents, and equipment. That part of the capital which is not permanently crystallized in these fixed forms — that part which remains in "liquid" form — is called the working capital, in contra-distinction to the other or fixed capital. As earnings or profits begin to come in and accumulate, the total value of all the assets of the company becomes something more than the original capital. This excess value is called surplus. From time to time, if the directors think wise, a portion of the accumulated earnings is distributed pro rata among the stockholders, profits so distributed being known as dividends.

That portion of the property of a corporation which consists of money or things which can readily be converted into money, such as good accounts due the company, bills receivable, marketable securities belonging to other corporations, or perhaps even readily salable merchandise, is called the "quick assets" of the company; while that portion consisting of buildings, machinery and equipment installed, patent rights, etc., which can not readily be turned into cash, is called the fixed assets of the company. This is a classification which has nothing to do with capital and surplus. A large part of the capital of the company might be in the form of quick assets, while conversely all its surplus might have gone into a form in which it can not be converted into money at all, as, for instance, in the case of a telegraph company which constantly put a part of its surplus into extending its lines.

A corporation may usually buy, own and hold the stock of another corporation just as an individual might own it. But in the case of railroads, this right has of late been considerably limited and abridged by statute. For convenience, to segregate its activities, or to avoid overstepping its charter, a large corporation will often organize a subsidiary corporation to carry on some contributing industry. A steel company might thus organize a subsidiary transportation company to haul its ore or products, or a subsidiary mining company to produce the ore, or a subsidiary tin plate or wire mill to work up its products. The parent company might then own all the stock of the subsidiary, appoint all its directors, and receive all its dividends, which would then go to swell the profits of the parent concern. Or it might sell part of the stock of the subsidiary companies in open market, retaining only a majority control.

There are many other applications of corporation law such as the organization of a holding company, or a construction company, which are of high ingenuity, but too frequently of very low morality. Many of them are designed to evade the intended limitations of corporate powers, or perhaps to segregate all the assets in the unassailable possession of one corporation, while all the liabilities are incurred by another. These devices are not creditable to American finance, and the evils they have created, the abuses to which they have given rise, are the prime cause of the public hostility toward corporations which is causing the present industrial disturbance and preventing a full measure of industrial prosperity. Such legal and financial legerdemain has no place in our consideration. We are concerned only with a brief general outline of the principal institutions by which industrial operations are carried on; and having now broadly sketched such an outline, we will proceed to an equally rapid survey of the methods generally followed in the particular department in which we are specially interested — the manufacturing or production department of a large organization. That is, we will resurvey the operations of organized manufacturing, not scientifically dissected and disconnected as in the foregoing chapter, but in actual operation.

The fundamental proposition is that nothing shall be made — no order to manufacture shall be given out — without authority of some duly authorized and responsible official. Whether the article to be manufactured is special, from special or original plans, or whether it is a stock article made by standard patterns, someone in authority " vivifies," by his signature, the order that starts the process of manufacture. Such an order to manufacture an article or a lot of articles is usually called a production order.

The production order is general. It may call for (say) "20, No. 2 milling machines," or "10 Eclipse engines, 8x12" or "100 type C, 10 k.w. d. c. motors." Every production order is therefore likely to involve several or many different items or acts of production. The production order is therefore first sent to the engineering or drafting department and is there reduced to these specific elements, although, in the case of strictly standard products, standardized lists of details may be filed in the production department and may be taken off as a matter of routine. In either case, the production order next appears as an itemized list of materials and jobs, immediately understandable by the shop officials. The superintendent of the shop or department or his duly authorized subordinates then secure the materials needed, by a requisition upon another department which has custody of all materials. This department is called the stores department. The materials being secured, the various jobs of work upon them are then given out to individual workmen, sometimes by a central work-dispatching office, sometimes by the foremen of the various departments. These separate orders to do specific parts of the work are generally called works orders or job tickets. Each job ticket, for convenience in accounting with the men, has its own serial number; but each job ticket carries in addition the number of the general production order to which it belongs.

Each work order or job when finished is delivered to the finished-stores department, or to the assembling or erecting department by which it is in turn delivered to the finished stores. Notice of the completion of the entire production order, or of each installment of it until it is complete, is returned by this finished-stores department to the office from which the production order originated — and the cycle is thus completed.

The original production-order number appearing on the ticket or instruction card accompanying each job passing through the shop serves to identify it and direct it surely to the intended destination, though it may be mingled among all sorts of other work at various points on its way. This is something like the way in which an address carries a letter to its destination, although that letter travels part of the way in the mail bag with thousands of other letters. Records of starting and finishing times for each job are made on the individual job tickets; these serve as checks against the total time of the workmen employed, and afford data for cost computations. Manifold copies of the production orders and the work orders, sent ahead to the departments participating in their production, notify these departments of work in progress for which preparation must be made. When the original comes through with the completed job it falls naturally into the files under the same number with the manifold, thus automatically announcing and identifying itself. Manifolds of which the originals have not yet appeared reveal work unfinished or delayed. You have here a hint at the basis of the system of stock tracing by which the operations of the plant may be kept up to schedule.

It will be noticed, probably, that the cycle of manufacturing begins and ends in the stores department. Before the operations can begin, material must be secured from the stores department by authorized requisition. When the process is complete, the finished goods are delivered to the stores department again for shipment or delivery. Indeed, material is supposed to be always in the custody of the stores department — is supposed to be and often is actually returned to the stores department after each successive step or operation in the entire process of manufacture. It is, therefore, frequent and very good practice to proceed upon the theory that the stores department is the responsible agency for seeing that a stock of both finished product and raw material is always maintained sufficient to meet the expected demands; that all shipping orders are issued to the stores department and not to the manufacturing department; and that whatever manufacturing orders are necessary for the maintenance of the warehouse stock of finished product, shall be issued by the storeskeeper. Even in the case of special machinery the same routine can be observed, except that in that case the finished product of course will not be stock and will have to be manufactured in accordance with the special designs after the shipping order has been received. A very important function of the stores department, therefore, is to insure against delays or interruptions either to manufacture or to shipment which would occur if items in the stock of either raw or finished goods were allowed to run out, and at the same time to avoid tying up an unnecessary amount of capital in wasteful idleness by keeping too large a stock either of raw materials or of finished product on hand. The actual procurement of raw materials is generally handled by a sub-department called the purchasing department, which is responsible for quality, prices, and arrivals of the requisite supplies, but makes purchases only upon requisition from the stores department, so far at least as materials are concerned. In many cases machinery, tools, fuel or equipment not classified as raw material for manufacturing purposes and not kept in the storekeeper's stock, are purchased directly upon requisition from departments by which they are used.

The last great industrial function recognized by a separate department is selling. In several senses it dominates the whole. Things are not usually made unless they can be sold. In cases of special manufacturing, such as machinery made to order from individual plans, the manufacturing plant produces what the sales department specifies.

In the case of standard stock manufacturing, like watches or sewing machines, it turns out an article for which the sales department can find a demand. On the other hand, the operations of the sales department will not result in profits unless they are carried on with a correct knowledge of manufacturing department costs, of the limits of the manufacturing department's ability or capacity, and so on. There must be close co-operation and co-ordination. The engineering department is to a considerable extent the co-ordinating center between manufactures and sales. But being a little nearer to the latter, it is usually found forming a subdivision or part of the selling department.

Certain very able critics have urged forcibly that modern tendencies, especially American tendencies, are toward overmagnification of the salesman and his functions, and underappreciation of the engineer and his capabilities. It is a natural frailty, whether human or commercial. The salesman is the man who brings the money in. The engineer usually directs its outgo. The man who visibly or apparently stands nearest to income and profits has the first consideration. But it is a serious fact that in a large way we have nationally devoted too much thought to obtaining and raising prices — a salesman's function — and too little to lowering the costs of production — an engineer's function. Attention to lowering production costs by cultivating higher efficiency, by eliminating wastes of material, of labor, of power, or of any other industrial element, is now at a phase of rapid increase. It is here that the greatest opportunity lies for the industrial engineer and the works manager.

THE NATURE OF EXPENSE

CHAPTER V

THE NATURE OF EXPENSE

LEAVING now the general principles of industrial organization and the institutions and agencies by which industrial operations are carried on, we may view the problems of manufacturing as they present themselves to the works manager and study the several elements of these problems from his characteristic point of view. In practice, the processes of manufacture fall naturally into four great divisions: — First, gathering materials of various sorts necessary to the product we plan to turn out; second, operating upon these materials in some way so as to change their form, condition, combination, location, or bulk; third, distributing again among buyers that which we have previously gathered and manufactured; fourth, overseeing, safeguarding and promoting the whole cycle. To put it more briefly, the steps are: procuring raw materials, making them into finished product, selling our goods, managing the business. To reduce it to four words, the functions are purchase, production, selling, administration. All are necessary to the conduct of a manufacturing business, but to the manufacturer's mind some elements in the scheme, such as outlay for material and direct labor, seem to be visibly embodied in the finished product, and these he calls "productive"; others, like the outlay for administration, are only indirectly identified with the finished product, and are classed by him as "non-productive." Therefore, as the manufacturer always thinks in terms of cost, every proposition in production appears in his mind as consisting of three terms — labor, materials, and expense.

Let us examine this position again in more detail and from a slightly different angle of vision. All business is carried on for the sake of making money. In the simplest conceivable kind of accounting, we would put down on one side of the account or in one place a list of everything we spend in the course of carrying on our business, and on the other side of the account or in another place we would put down a list of everything we receive. The difference between the sums of these two lists would be our profit.

Now if our business is manufacturing, we shall always find, if we examine the items on the debit side — that is, the list of expenditures — that these items fall naturally into three great groups corresponding to three distinct sorts of thing for which our money has been expended. One of these groups will contain all the expenditures for the materials we use in our manufacturing — iron, steel, brass, wood, cloth, whatever it may be. The second of the three great groups into which we can divide our expenditures will contain all the outlay for labor — the money that we have paid to men for working and making up these materials into our manufactured product; and the third of the great groups will contain a list of expenditures for things that do not go into our product as labor and materials do, but yet are necessary to carry on the business. Such items are advertising, selling, office salaries, insurance and repairs and so on. This third great group of expenditure, then — this group of items of outlay for things that are necessary to carrying on the business and yet do not go directly into the product — this is called expense.

In one sense there is not an absolutely hard and fast line between these three classes of expenditure. In one sense expense overlaps, so to speak, both material and labor. For example, in a foundry, moulding sand is physically speaking "material." In a brick yard, lumber for runways is in the same sense a "material." But in neither case does it go into our product. It is not sold with our product. We can not find or weigh or measure a fragment of it in each piece of our product. It is used up and disappears, but the cost belongs to the business as a whole.

So men carrying messages about a factory, or carting shavings from a planing mill, are humanly speaking "laborers"— labor. But again they are doing work that can not be directly charged to any particular job — it is part of the necessary general cost of the work as a whole.

From the accounting point of view, then, the deciding question is — does the material or the labor go directly into product; can we trace it there and say definitely "so much material and so much labor make up this article"— or does it merely serve in some general way the making of all or many of the articles we are turning out? If the latter, then it is an expense item, to the accountant, even though in a dictionary sense it might seem to be material or labor.

Some accountants recognize this sort of double character of certain items by calling them "expense material" and "expense labor." It is more common, however, to speak of the three divisions of cost as direct material (or simply material) direct or productive labor, and "expense" including in the latter term all indirect material and labor.

Whether the manufacturer's money is expended for materials, for labor, or for expense items, he has one great general object, and that is that it shall be expended wisely, economically, and efficiently. But when we get beyond this first principal purpose and care, which is always in a manufacturer's mind, we can readily see that the things to be considered second are of different and characteristic natures in the case of materials and of labor and of expense.

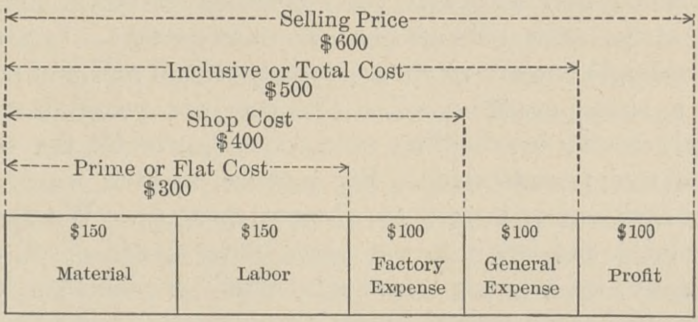
The points in which the manufacturer is especially interested, so far as concerns materials, are to make sure that they are provided and maintained in sufficient quantity for the operations of manufacture to go on without interruption, that receipts are verified, materials on hand properly stored and cared for, and materials in manufacture moved safely and in an orderly way from process to process until the manufactured product is complete.

In the case of labor the manufacturer's leading care and anxiety is to secure enough workers of desirable quality, to keep them contented, to increase their productivity, and to keep track of their time.

The fundamental problem of expense is distribution. That is, if our business is to be intelligently and successfully carried on, after we have accounted for the money that we have paid for materials and found out how much of it has gone into each unit we have manufactured, and after we have paid for our labor and accounted for the time and wages spent upon each unit of our product, we must be able to take the rest of our expenditures — the confused total bulk of general expense, which is neither direct labor nor direct material and to divide it up into a multitude of little fractions, each corresponding to one unit of our product, and we must make this division and "levy this assessment" so that we can say confidently that we have charged each unit with its fair, reasonable, and just proportion; that we have assessed to each unit of product the actual cost of the material that went into it and the labor that was put upon it, and its proper share of the general expense of carrying on the business. If we do this correctly we are sure that when we have added to these costs a proper percentage of profit, we will make money if we can find a market for our goods.

The importance of being right about it is this: If we make a mistake in the distribution and charge some one line of our product with more expense burden than it ought to bear, a clever competitor who knows his costs better than we know ours, will make a lower price which still leaves him a safe margin and he will undersell us and take away our market. If we charge some one line of our product with less expense burden than it ought to bear, we shall probably get the business in that line away from our wiser competitors who are asking correct prices, but the more we sell the more money we shall lose.

In other words, the reason that makes it necessary to have a correct knowledge of our costs is competition. And in the correct knowledge of costs, the most difficult and at the same time the most necessary thing is the correct distribution of expense. Mr. A. Hamilton Church, who is one of the leading authorities on the distribution of expense burden, says: "Very few concerns have come to grief by ignoring labor costs" (or he might add material costs), "but many have passed into the hands of receivers by ignoring the relative importance of other factors of production."



We may represent by this simple diagram the several fractions making up total costs, and the several parts of which the final selling price of an article is made up. The relative proportions of material and labor, factory expense, selling expense, and profit vary widely in different cases. The proportions used in the diagram are wholly arbitrary, but are not improbable.

The figure serves to show the significance of the terms commonly used in cost accounting, and to emphasize the division of expense into two parts, the first called "factory," "shop," or "manufacturing" expense, and the second called "general," "commercial," or "selling" expense. This division is commonly in use and is logical. There is no necessary connection between the expense attending the making of an article and the expense of selling it. They may be relatively very different. There is hence no reason why these two expense elements should be distributed at the same time or in the same ratio, and indeed there are many reasons why they should not.

The discussion following will leave until last the rational mode of apportioning general expense among the varied products of any establishment, and will take up first and at greatest length the distribution of factory expense.

Now if our product is simple and all of one kind, the determination will be easy enough. It is when product is diversified that accurate cost accounting becomes difficult and at the same time becomes more important. Suppose, for example, we are running a cotton-seed oil mill and making a single grade of oil. The cost per pound is very simply found by dividing total expenditures by the total number of pounds made. But suppose, further, we decide to branch out and work up our own product. We install a refinery and begin to put out a fancy grade of oil for table use; we get up a "lard substitute"; we install a soap works and make several grades of toilet and laundry soap; we follow with a glycerine plant; and finally we manage to do something with several kinds of by-products. Now we have a number of different products, selling at very different prices, in different markets, and under different conditions of competition. There may be big money in lard compound, while the soap market is so hard pressed by competition or so captured by large manufacturers who lavish money on advertising that we can not sell soap at a profit. But unless we know accurately what lard compound costs us per pound, or what soap costs us per box, how can we tell that there is a profit in one and a loss in the other? How can we know that we should put all our raw material into lard compound and cultivate that market, and that we should shut down the soap factory? Knowledge of costs is the guide to success and, indeed, a necessity to existence in modern commercial manufacturing.

In this exact determination of costs the most troublesome factor as already stated is the element of expense. Material and labor are fairly concrete, definite and tangible things. We can see them, weigh them, measure them, and connect them directly with the product they assist to form. If we take any single article in the whole output of our plant, whether it is a pound of cottolene, a cake of soap, a hat, a globe valve or a dynamo, we should be able by comparatively simple records and accounts to know exactly the value of the material that went into it, and exactly the outlay for the direct labor that has been expended upon it.

But in the total expenditures of any manufacturing business there is a very large outlay (usually a very large fraction of *all* the outlay) that is *not* for material, and is *not* for labor, and yet we must get it back from our customers. A proper proportion must be repaid to us in the price we get for each bit of product we sell. If each article sold does not repay us for its just proportion of these general expenditures, as well as for its just proportion of material and labor, our business will be headed toward failure and not toward success.

It is these miscellaneous expenditures, not of themselves productive of anything and yet necessary to the production of things, that make up the expense account.

Among them are rent or interest on the cost of land and buildings, insurance, repairs, salaries of general officers or officials, of clerical staff and all unproductive labor, power, light, heat, legal expenses, advertising and selling, etc. The total is a load bearing upon the extra business, and each item of product must carry its share — hence the figure of speech, " burden."

The distribution of expense (that is, the assessment of a just and proper fraction of it as a part of the cost of each item of our product) is not only one of the most difficult, but also one of the most controversial and most unsatisfactory problems of works management or shop accounting. This is because expense is not like the material and labor components of a manufactured product, which are absolute, concrete factors — known quantities that are permanent, fixed and absolute in value. The expense component of any single item is really an elusive variable, to which we give a value arbitrarily taken because it solves some particular case or problem.

Let us illustrate the point again by means of a pocket-knife. Let us suppose the simplest possible conditions — that we are making nothing but one kind, size, and style of knife. Suppose our cost records show that the material used in this knife is worth 20 cents, and the labor that made it another 20 cents. Our prime or flat cost, as it is called, is 40 cents. We find, perhaps, that by the most careful and correct compilation and distribution we can make of all our factory expense (that is, our expenditures for things other than material and direct labor), this knife should be burdened with an expense charge of 10 cents — that is, it should be considered to have cost 20 cents for material, 20 cents for labor, and 10 cents for expense, in order to return to us our entire manufacturing expenditure. Let us suppose that of this 10 cents expense burden 1 cent goes to pay this knife's proportion of the president's salary, and 1 cent goes toward the general manager's salary, and 3 cents go for other office salaries, and 1 cent goes for rent, and 1 cent for the coal bill, and 1 cent for general repairs and 2 cents for sundries.

Now suppose we had not made this particular individual knife. Our cost facts as to material and labor would prove their absolute truth by transposing the equation. We should actually save 20 cents for material and 20 cents for the labor. That 40 cents would remain unexpended and we should have it in the treasury. We would save 40 cents in actual money by refraining from the manufacture of this particular article. But our assumed expense fact goes all to pieces. We do *not,* by not making this knife, save 1 cent on the president's salary, or 1 cent on the general manager's salary, nor do we reduce our rent, or lessen our repairs, or cut down any of those other expense items (except possibly the coal) by the figures we attributed to the expense burden of this individual knife. What does happen is that all the other knives we do make have to bear between them just the same total expense as before, or a little larger expense burden each.

But let us not leave this example without noticing another point. We have remarked so far that a difference of even one knife more or less in our total product makes a corresponding actual difference in our total outlay for material and labor, but practically no difference in our total expense account; and we have deduced from this that a scheme of expense distribution that is true for a certain volume of output becomes untrue at any other volume of output, whether larger or smaller.

It would be incorrect, however, to assume that the expense burden as a whole does not ever vary, or indeed that it does not vary considerably, with varying volume of business. The truth is that expense burden is made up of a large number of elements, some of which go up and down in general correspondence with the volume of business and some of which do not. In other words, our total expense is divisible into two classes — constant and variable. The former division (constant expense) includes all expense items necessary, so to speak, to the mere *existence* of the business, while the latter division (variable expense) includes all items connected with the *activity* of the business.

For example: In the constant-expense section we should include rent, or its equivalent in interest, insurance and taxes, if we own our real estate and buildings. This clearly remains uniform or unchanged, whether the factory be busy or idle. Another such item is the salaries of general officers; they draw their pay the same in good times or in bad. It is true that on a very great expansion of business we might have to acquire more ground and put up more buildings, or rent more space, or enlarge our organization and add more salaried officers. Or in very dull times we might give up some of the property we have been renting and we might cut down official salaries; and so these so-called constant expenses may change. But if they change it is by occasional large steps of this kind. They remain level for long periods, and there is a minimum below which they can never go if the business is to continue to exist at all.

On the other hand, expenses like advertising, selling, correspondence, clerical assistance, drafting, power, transportation, foremen, yard labor — all these go up and down on curves corresponding closely and quite sensitively to the amount of business we are doing, and many of them can be completely cut off if the plant is wholly shut down.

So the second great point to keep in mind is that while the ratio of expense to productive labor and materials (or in other words, the proportion of our total cost chargeable to expense) is variable and is constantly varying in a way that from an accounting point of view is very troublesome, this variation is caused by the fact that a certain very large part of our expense account is constant, or nearly so, however our total volume of business may vary. It sounds like a paradox, but the *proportion* of expense varies because the *total* of expense does not. This fixed necessary outlay stands little changed from month to month, while the gross income against which this is balanced fluctuates now up and now down.

The result is that as business becomes more active the expense *ratio* drops even though the expense *total* may rise, while as business shrinks the expense *ratio* rises even though the expense *total* may fall. This is the reason why in dull times dividends on industrial and railways stocks are so frequently reduced or passed. Business may be (say) 50 per cent of normal; purchases are cut down, hours are shortened, employees are discharged, trains are laid off, purchases of material are suspended, actual operations and expenditures for actual production are cut down to one-half — but profits do not remain at half the normal. They vanish entirely and a deficit appears instead because the irreducible constant expense eats all and more than the gross profits earned by the 50 per cent activity.

To come back now to our imaginary knife factory; we see that while we may be certain enough what our whole expense account amounts to, the assumption that the individual expense burden chargeable to each individual knife is 10 cents *is an assumption only*. It is a convenient approximation to truth which holds good under average conditions, but begins to depart from truth as soon as and as fast as conditions depart from average. That is the first difficulty in distributing expense burden.

But suppose, further, we are making not only pocket knives, but also carving knives and safety razors. We can tell exactly how much material and how much direct labor each pocket knife, and each carving knife and each safety razor takes. We can tell exactly how much our total expense is. But how shall we tell just how much of this total expense is occasioned by the manufacture of a carving knife, of a safety razor, or of a pocket knife, or whether there is more general expense occasioned by the manufacture of one of these articles than by another? Does forging a carving blade consume more power and use more coal than forging a pocket-knife blade, or does timekeeping and clerical labor run higher in the safety-razor shop than it does in the pocket-knife department? Should, therefore, each carving knife or each safety razor (for these and other similar reasons) bear a larger burden of expense than each pocket knife? If so, how much?

May be the carving-knife account does not show satisfactory profits, and we think of giving up that branch of the business. But are the apparent profits small because we are charging it with more than its true share of expense, and thus relieving the pocket knives and the safety razors of some of the burden they ought to bear? If we drop the manufacture of carving knives, will our expense account drop by the amount of burden we have been charging up to the carving-knife department, or shall we still find the same old expense totals bearing now wholly on pocket knives and safety razors and shall we be worse off rather than better? Would it be sound policy, instead of abandoning any line, to add still another that would bring a reasonable profit over the flat cost of materials and labor, in the expectation that in fact no increase of expense would be occasioned, and we should be just that much ahead on our total profit and loss account?

Here we see the second difficulty in the expense distribution, which is to apportion the total properly among the several or many lines of product in a varied manufacturing business, so that the calculated costs of each (on which we base our selling prices) may be as near as possible to truth. Then whatever line may expand or contract we shall be safe from disastrous disappointment in the total of our profits.

In order to see more clearly how the proportion of expense justly chargeable to various lines of products may vary — that is, how various components of expense are created in unequal proportion by various classes of manufactured goods, and hence should be borne with corresponding inequality by these various classes — and to see also some of the considerations affecting the distribution of expense, let us imagine that we are making a hasty tour through a machine-shop and let us see in part how and where the burden is created. We will assume that the shop makes its own castings and we will begin with the foundry. The material (pig iron) and the labor of molders, helpers, core-makers, etc., on each and every job and piece, can be pretty closely recorded, so that our material and direct-labor costs are reasonably exact. But here are some men who are not engaged in making any special casting into which their work goes and to which it can be charged; they are wheeling sand, shaking out flasks, charging the cupola. Here is coke going into the cupola to be burned, and power being used for the cupola hoist and for furnishing the blast. Without searching any further, we find already an aggregated outlay — an expense burden — which we can not attach to any one piece of material or to any one job, but which we must distribute somehow among all the jobs done that day or on that melt.

We see however, further, that there is another cupola on which men are busy making repairs. Evidently there is an outlay for refractory linings, labor, and incidentals, which must somehow be loaded on to the foundry product and repaid by its sale. We must keep our cupola in repair; it costs money to repair it, and we must manage to get our money back. But this expense was incurred through wear and tear attending the melting of iron for all the castings made in a week or a month, perhaps. Our total of this repair bill, then, must be distributed over the jobs of that whole period if each is to bear its fair burden.

We see, further, that other men are at work removing dust from the rafters, repairing the roof, and white-washing or painting the whole foundry building. They are remedying the deterioration or decay of possibly a year. Again, money spent in general expenses, to be recovered in the sale of product. Here is another item of burden to be spread over a still wider section of our output.

Here, in all these cases, we have burden limited in distribution according to *time*.

We pass to the machine-shop, and we see a large overhead crane transporting a heavy engine bed to the planer. The crane itself represents invested capital which is disappearing constantly year by year as the machine in which it is invested wears out. Furthermore, it costs money to run that crane — money for interest on the investment required for its installation, for power to run the crane, for the man who operates it. Some of this cost accumulates night and day, whether the crane is running or is idle; some accrues only when it is in operation. But it accrues, and we must charge it against our product somehow and get it returned to us with profit. Evidently, though, it would be unfair to levy any of it against our lighter lines of manufacture, which do not need crane service and never use it. On the other hand, here is a little industrial railway used for moving light and medium-weight pieces around the shop. This is an expense item of similar sort, but here the burden is not chargeable against heavy product.

Here we have burden limited in distribution by *weight or character of product*.

We enter the lathe department and find a foreman in charge. His wages are paid him every week and enter into the total of our manufacturing costs, but they do not appear on the job tickets for any of the individual items of work handled on the lathes. His wages, also, then, must be taken care of in the manufacturing-expense burden; but they are incurred in connection only with the lathe work, and in justice no fraction of them should be attached to any of our manufactured product which has not had lathe work done upon it.

Here we have burden limited in distribution by the *character of operation.*

As we pass through the shops, we notice here and there a timekeeper at work, securing data as to the times when jobs had been begun or finished, and here as we approach the offices is a room where several clerks are entering the time records and computing premiums or bonuses. Evidently this is a necessary auxiliary to our productive system, although it is itself unproductive. The cost of the employment of these clerks and of attendant expenses must go into our burden; what particular fraction of it is theoretically attached to any particular machine we manufacture and sell, obviously should depend upon the complexity of that machine — the number of parts, and hence of operations and times, which had to be recorded, and the demands its computations and calculations make upon the time and services of the time clerks. Here we have burden varying according to the *complexity of the product.* Next, if we look into the sales office (as we should do) we shall see a probably large and expensive force of men, with the aid of considerable outlay for office assistants, advertising, and publicity work. The total of this expense — of this commercial burden — must be taken care of, and if we look into it we shall probably find that the necessity for these expenses varies very widely between different lines of our manufacture. Standard product disposed of through dealers probably almost sells itself. Special business, or new business for which the market must be created, probably costs a great deal to work up. Here we have burden varying according to *commercial conditions.*

It will be apparent from the view we have had so far that no absolute, mathematically correct and invariably true distribution of expense can be made. We must accept some reasonably fair distribution that will serve within allowable limits of error under ordinary fluctuations in business, and we must give separate and careful attention to extraordinary conditions that may make our methods and figures, temporarily at least, inaccurate. The methods generally used are more or less rough-and-ready approximations, convenient to use, sometimes as misleading as they are convenient, but often quite good enough for practical purposes, especially as the experienced industrial manager has a sort of sixth sense, or specially trained common-sense, by which he corrects the occasional false readings of his cost system.

These methods will be outlined in the following chapter.[1]

[1] A very thorough discussion of this subject will be found in "The Distribution of Expense Burden," by A. Hamilton Church; *The Engineering Magazine.*

DISTRIBUTION OF EXPENSE

CHAPTER VI

DISTRIBUTION OF EXPENSE

ONE underlying idea appears in all the methods of expense distribution or apportionment that are commonly employed. It is this: Expense, as has been repeatedly pointed out, does not naturally connect itself with individual jobs or individual units of product. It gathers like one general cloud over the whole business, but not in distinct wreaths around each transaction. Material and direct labor, however, *do,* from the beginning, identify themselves with individual operations or individual units of product. You can almost see each job, as it goes through, attach to itself successive items of material and of work. You can see each man and each machine putting material and work together, in visible and measurable quantities, until each piece of product is completed. Now, the underlying idea of all methods of expense distribution or apportionment is to use some one or more of these visible, tangible, measurable elements as a gauge, and to pro-rate the expense allotment by it. That is, they burden each job or each unit of product in proportion to the material that goes into it, or the wages paid for it, or the time spent working on it, or the use it makes of the machines and other facilities in the factory. This gives us five cardinal methods of expense distribution: By material, by percentage on wages, by man hours, by machine rates, and by production factors. We will take up their operation and their characteristics successively.

Distribution of expense by material is a method of limited applicability. Its usefulness is confined to comparatively simple industries such as metallurgical or structural-material works, where the product is nearly or quite uniform. In a brick yard, or a blast-furnace plant, or a gas works or perhaps in a pipe foundry or other establishments of like character, it may work as well as any other plan, simply because there is no need of distribution, properly speaking, but only of equal sub-division. Indeed, if the product of a plant is absolutely homogeneous — all just alike — it makes no difference whether you apportion expense by count or weight or measure or flat cost — you can not get wrong as between one unit and another. An expense rate per ton or per thousand is quite sufficient for purposes of estimating or for comparison between one period and another. But when the product is not all alike, the introduction of material into expense-distribution calculations only confuses and distorts results. In the remaining methods, therefore, we shall hear no more of material or value of material.

The percentage-on-wages method of apportioning factory expense is probably the most generally used. As a starting point in this method, we take the total for a given time (say a month or a year) first of the wages of the productive labor during that period, and second of the factory expense during the same period, and we find what is the percentage relation of the expense to these wages paid to productive labor. Suppose we find that the total factory expense is 60 per cent of the direct labor payroll; then we load every job done during the period with 60 cents additional for each dollar of direct wages that is expended upon it. If we find, for instance, that a certain small steam pump is shown by the job ticket to have cost $50 for material and $100 for labor, we add 60 per cent of $100, or another $60, for the factory burden, and obtain as the shop cost of the product $50 *plus* $100 *plus* $60 equals $210.

If our output is all substantially of the one general class, and if the various machines, tools, or pieces of apparatus in our manufacturing plant are not very different one from another as to expense of operation, and if our wages are fairly uniform as between one operative and another, the results obtained by this method will be quite accurate. But if we have a great difference in equipment, having some very small machines taking little room and power, and cheaply operated, and some very large machines taking up a great deal of room and power, and involving large expense for operation and wages; if we have passing through the shop some very heavy work and some very small and light work; if some of our labor is highly paid and some is very cheap — this method may lead to very inaccurate results. A job of fitting, taking 50 cents worth of a man's time on a little bench lathe, tucked away in an otherwise useless corner, would be burdened just the same as a job taking 50 cents worth of a man's time on a huge costly boring mill, occupying the whole end of a building; for the percentage-on-wages method recognizes only the one visible factor of money paid for human labor and ignores differences in the extent to which different items of product make use of mechanical equipment. As a large proportion of the expense burden arises from the cost of installing and repairing machinery, and moving product to and from the machines, we can not arrive at true results by a method of averaging that allows no weight to this particular factor.

The third method is the man-hour plan. It varies from the preceding system in that the distribution is made proportionate to the *time worked* on each job instead of to the *money paid* for that time. At the first glance this might seem like the same thing, but on further consideration it will become evident that there are important differences. For example, suppose we take a job away from a $3-a-day man, and give it experimentally to a good clever $1.50-a-day helper who completes it in the same number of hours.

that his predecessor did. Under the man-hour plan it will still carry the same expense burden as it did before, because it takes the same time. This is a correct result, for the mere change of operative has not changed in any way the demand which the work makes upon the general organization and facilities of the plant; has not changed in any way the amount of expense it creates, and hence should not change the expense apportioned to it. But under the percentage-on-wages plan, as we saw a few moments ago, the expense burden distributed to this job would have been cut in half by the mere fact that the man who did it was a $1.50 man instead of a $3 man. Suppose, on the other hand, the $1.50 man proves clumsy and inexpert, and takes twice as long as the $3 man did to finish the job. Under the man-hour plan the job would be burdened twice as heavily for expense — as it ought to be, since it has been twice as long occupying floor space, occupying space on the machines, taking the attention of foreman and timekeepers to look after the bungling job. Under the percentage-on-wages method, as we saw, this slow job, done by the cheap man, clogging up the shop and delaying the progress of other work, would be charged with just the same expense burden as the job done in half the time by the competent man, because the total wages were the same in both cases.

In some particulars, therefore, the man-hour plan is more correct than the percentage-on-wages plan, but when we look a little further we find that, like the percentage-on-wages plan, it takes no cognizance of the machine element. All jobs taking two hours are burdened the same, whether the two hours' time is on a valve-seat grinder or on the largest engine-bed planer in the shop.

The machine-hour method of expense distribution makes a much closer approach to accuracy than either of those so far described, because it recognizes the fact that in modern manufacturing the producing unit is not a single individual, but a complex combination of the machine or piece of apparatus, the man or men tending this machine, the equipment surrounding the machine, and the suitably prepared space necessary for the installation and operation of the machine. In further explanation of this method of expense distribution the term "machine" is used in a general sense, with the understanding that it includes anything from a soap kettle to a jeweler's lathe.

In the administration of the machine-hour method of apportioning factory expense, the preliminary step is to determine on an hourly basis the cost of running each machine in the works. This cost includes the charge for rental, lighting and heating of the space the machine occupies, and the surrounding space necessary for its operation; interest on the cost of the machine and allowance for repairs and depreciation; cost of power to run the machine; cost of services, such as cranage and transportation of various kinds to feed or to remove materials; cost of indirect labor attendant upon the machine; any incidental or special expenses; and a just proportion of the general burden of administration, superintendence, non-productive factory labor, etc.

Having obtained the totals of these various charges for a month or a year, they are divided by the number of hours during that time the machine can be expected to run, this figure being reached by a careful study of past experience, and if necessary corrected by later actual observation. The quotient is the hourly rate of that machine. Every job coming to the machine is then assessed with this charge for the number of hours or fraction of an hour it spends on the machine.

Evidently, if each machine in the plant is thus rated, and each job coming to each machine is thus assessed with its individual expense burden, and if all the machines are in operation during the normal and expected portion of the time, the whole expense burden would be distributed in close accordance with the use each job has made of the facilities of the shop. This seems as fair a basis as could be found. The trouble begins when the activity of the plant differs largely from normal. The machine rates then distribute too much or not enough to cover the actual expense, according as the plant is running overfull or is partly idle. This, however, is the unavoidable difficulty caused by the inherent nature of expense, as pointed out at the beginning of this study. When too much expense is thus charged against the jobs of an active period it may be allowed to go as a reserve to be drawn upon in a sub-normal period, or it may be credited back to the operations of that period *pro rata*. When too little is charged, the undistributed expense remains to be apportioned by what Mr. Church calls a "supplementary rate," either on an hourly basis or in the same proportion as the original machine rate.[1]

There is another perplexity in the use of machine rates which need not be discussed at length here, but should be noted in passing because of the active discussion it excites amongst accountants. Suppose a small job, which comes along when its regular machines are all full, is done for convenience's sake on a heavy and expensive machine that might perhaps otherwise have stood idle; this normally inexpensive little job is charged under these peculiar circumstances with the high machine-hour rate, corresponding to the expensive machine on which it was accidentally done. The result is that its cost appears abnormally high. If used as an estimate for further transactions this cost would lead to distorted results. Yet if it is not used, the rigid accountant says, we are doctoring our records and taking costs not as they were, but as we thought they ought to have been.

This is what is known as the problem of the penalized job. It is somewhat academic, and we will not go into

[1] "The Distribution of Expense Burden."

it further than to point out that if the case arises very often in the practice of any plant, it suggests some inefficiency in the balance of the equipment which may be remedied by proper changes.

Expense distribution by production factors is an extension or development of the machine-rate method influenced by a new way of looking at the whole process of production. The central idea of it, as developed by its sponsor, Mr. A. Hamilton Church,[1] is that manufacturing is carried on by a combination of what this authority calls "services," of which labor is but one. On account of its vitality and visibility, labor (in Mr. Church's view) has been given undue prominence and placed by itself as if it were the only direct factor and standard by which everything else is measured, while the various other services have been dumped into the expense account which is afterwards redistributed by some method of approximation or average or percentage on labor, as we have just seen.

Mr. Church's production-factor method proposes to restore these various services to separate individual recognition. In place of the heterogeneous general expense account, he would keep separate accounts with every identifiable factor of service other than labor, and then he would apportion these separate factor accounts separately, each by a logical method representing its actual relation to the various lines of manufacture carried on. The principal of these services or production factors other than labor are Land and Buildings, Lighting Heating and Ventilation, Power, Stores and Transport, Organization, Management and Supervision. These are distributed by various methods of apportionment, Mr. Church's test question being always: "How would a manufacturer pay for this service if (as might be the case with light or power or land and buildings) he purchased or

[1] "Production Factors in Cost Accounting and Works Management," by A. Hamilton Church; *The Engineering Magazine.*

hired it from an outside source instead of mingling the supply of it with his own characteristic function as mere manufacturer?" Thus, the expense attendant on the provision of land and buildings, or of light, heating and ventilation, is distributed on the basis of square feet or square yards of floor space, or, to use Mr. Church's term, on "capacity-area"; power is distributed by horse-power years or horse-power hours; stores and transport are assessed departmentally, with consideration of the weight, bulk, activity of movement, and other matters affecting the actual cost of storage and movement of materials. These separately distributed rates are then combined into hourly rates applying to various so-called "production centers," a production center being a machine, a group of machines, an individual work bench, an area of floor space, or any distinct element in the process of manufacture; these hourly production-center rates are then imposed on individual jobs, as these jobs in their progress employ the time of the different production centers.

The system evidently demands elaborate preliminary study, but when the production-center rates have once been determined the application thereafter would be no more intricate than that of the machine-hour rate, which is in practical and highly satisfactory use. So far as I know, the complete production-factor method of expense distribution is not yet in service anywhere. It would produce, as Mr. Church points out, one highly valuable result — that intelligent comparison of costs in different establishments could be made and the quantitative effect of, say, expensive power in one locality, high rent in another, over-elaborate organization in the third, and so on, would become instructively apparent. At present it is rarely possible to contrast costs in different establishments with any effective practical result, or at least with any clear discovery as to why they vary, or just what points are more efficient in one than in the other.

Of all the expense-distribution systems outlined, the machine rate probably best combines practical workability and a reasonable approach to mathematical correctness. It is not as scientific as the production-factor method, but it is much more within the comprehension of many industrial managers and within the powers of the average industrial accounting staff. When it is used the machines are often grouped into classes and class rates are determined instead of individual rates for each and every machine. Probably only progressive managers will go even as far as this; but this far they will go, and have gone, and the method is in every-day use and has been in use for years in some important establishments. Most plants, however, will still refuse to consider anything but the percentage-on-wages or the man-hour plans. Either of these can be made fairly correct for ordinary purposes, even with diversified product, if this product is classified into homogeneous groups, and an appropriate percentage apportioned to each group, corresponding generally to its relative expense-creating characteristics.

So much for factory burden.

The treatment of the general expense presents substantially the same sort of problem as the distribution of factory expense, but the elements composing it are not as many nor as complex, and hence the process is not as intricate. The principal components of general expense are correspondence, advertising and other forms of publicity, selling, collecting, accounting, and office administration. The principal danger against which accountants generally have to be warned is that of assuming that the scale used in distributing factory expense may be used also for general expense. There is no necessary relation whatever between them; that is, there is no necessary correspondence between the proportionate expense of making an article and of selling it. A sufficiently satisfactory method of distributing general expense is what might be termed an apportionment by inspection: That is, we take our principal classes of product which in one line of business might be bank vaults, safes, and steel furniture, or in another line of business might be chain blocks, locks, and architectural iron work. We next take our principal general-expense accounts, which may be correspondence, catalogues, general advertising, salesmen's salaries or commissions, and traveling expenses. We decide from the general characteristics and circumstances what proportion of each of these accounts is fairly chargeable to each line of product. And finally we reduce the resultant totals to a percentage basis. This is not a scientific mode of solution. No mode of scientific solution is possible. The element of judgment enters largely into our analysis and distribution of the various accounts — but, as Mr. Church says, "there is a great difference between judgment and mere guesswork," and by taking the various items of expense in detail we arrive at a result immensely more valuable than any that could be reached by guessing at the whole lump of expense.

The expense accounts we have been discussing, although they appeared to be indirectly connected with individual units of product, nevertheless have been actual accounts, sums of money positively and visibly expended. There is, however, another element in the cost of manufacture closely associated with expense (so closely that I have not heretofore referred to it) and yet characterized by qualities quite distinctively its own — qualities which differentiate it from expense and suggest the need of a different mode of treatment. This last element of cost is depreciation. Depreciation is the decrease in value of our property, that is, especially our buildings, machinery, and equipment, by the fact that it is growing older and is drawing nearer the time when it will be worn out, or when through some change of conditions, processes or methods it will become obsolete, and will have to be discarded, scrapped and replaced by something new. We must therefore anticipate this inevitable depreciation by estimating in our costs, and recovering from our sales, a reserve fund, thus accumulating in advance a fund from which the depreciated equipment may be replaced. Our cost must include not only the material and the labor that have actually gone into the product, *plus* a share of the expense burden actually incurred. It must include further a factor for something that has not yet happened, or at least has not yet materialized in the form of an expenditure incurred and recorded on our books. We must provide for the depreciation which is going on day by day, even though it may not make itself evident for a long time to come, or until the wear and tear have grown serious enough to require overhauling or replacing of the depreciated item.

In reckoning the allowance to be made for depreciation, we have not only the same difficulties that we have in the case of expense,— that is, the difficulty of apportioning an indirect account to direct classes or items of product — but we have the additional problem of determining what amount we must thus apportion.

We have seen that authorities differ in their treatment of the expense account. They differ more widely and aggressively yet over depreciation. Some treat it rather curtly, almost with indifference, maintaining that where repairs and renewals are consistently kept up, depreciation need be recognized only by comparison of annual inventories and the use of such averaged figures as may be thus disclosed. At the other extreme, some accountants argue fiercely that depreciation should be assumed at an arbitrary percentage of the value of our equipment, and they split hairs in the debate whether this percentage should be taken always on the original investment, or each succeeding year on the investment as reduced by preceding deductions.[1]

It is a proposition upon which it is perhaps impossible to generalize except perhaps to this extent:

First, that it is very dangerous to regard investment in short-lived equipment (such as small tools, for example) as a plant account — a part of our fixed capital — at all; it should be considered an expense and so charged at once, or if carried as an asset should be given only a nominal value.

Second, that items of intermediate permanency such as drawings, patterns, should be credited as an asset only at a fraction of the cost and a very high factor of depreciation should be applied to them year by year until they are charged off and disappear.

Third, that as to the permanent items such as machinery, apparatus, power-plant, heavy tools, structures, etc., the chief danger to the continuance of their value is not so much that they may be destroyed by wear and tear as that they may be superseded by some new and radical development. Suppose we are building large reciprocating steam engines: Our costly drawings, patterns, templates and equipment for a great horizontal and vertical compound type may be made obsolete in a year or two by the introduction of the steam turbine. Suppose we are operating a cable-road: our power-plant may have to be scrapped to put in electric traction. Suppose we own a bicycle factory: it may be thrown into idleness because the popular whim turns to tennis and golf. Suppose we are prosperous manufacturers of tin-plates in Wales: our mills may be closed by the Dingley tariff in the United States. Suppose we are proprietors of a machine-shop: it may have to be remodelled throughout and largely re-equipped for electric driving and the use of high-speed steel. In some of these cases, even, it might be

[1] A standard work on depreciation is "The Depreciation of Factories, and their Valuation," by Ewing Matheson; E. & F. N. Spon.

argued that the renewal expense should not be charged against the profits of the past as a depreciation, but rather as a new investment justified by the larger profits obtainable in the future through the improvement. Others might be held to be "risks of the business" rather than cases of depreciation. If we are to provide for such contingencies by a factor of depreciation, depreciation becomes to a certain extent a sort of insurance against an indeterminable risk. It is prudent to provide for it; to consider that certain future expense not yet visible is yet inevitable; to assess a provision for it as a part of our calculated costs, and to set aside a corresponding share of our current receipts as a reserve fund to meet the contingency. But what the factor should be in any given case I think can be determined only by the method of inspection and the exercise of deliberate and intelligent common-sense.

There is, however, a certain ethical consideration, as pointed out by Prof. L. S. Randolph,[1] which should not be overlooked when a rate of allowance for depreciation is determined. It is this: In industrial and corporate undertakings generally there are usually at least two classes of ownership interests, typically represented by the bondholder and the stockholder. The bondholder lends capital on the security of the actual physical property. In view of this security he lends the money at a comparatively low rate of interest, looking to this physical property for the ultimate return of his principal. The stockholder seeks his return from the profits of the business and generally expects to receive a higher rate of interest. He owns the business, subject only to the lien given to the bondholders for the borrowed capital. He manages the business. Its success is proportionate to his skill and ability and all surplus earnings accrue to him.

Now if in calculating and distributing his profits the

[1] *The Engineering Magazine,* August, 1910.

stockholder does not make proper provision for restoring wear and tear, replacing worn-out equipment, and maintaining the value of the plant, which is the bondholder's security, he is not keeping up the value that he has pledged against the money borrowed from the bondholders. He is not dealing fairly with his creditors.

If, on the other hand, the stockholder set aside an unnecessarily large proportion of his gross earnings for a depreciation fund, thereby diminishing his apparent net profits or his surplus available for dividends, this fund nevertheless remains in his hands for administration and need be drawn upon only so far as actual depreciation occurs, the remainder reverting to the stockholder, so that he does himself no wrong. This is, in other words, an argument for a high rather than a low depreciation allowance.

Clearly, the distribution we have been talking of is all retrospective. It shows us the dollars and cents of *what we have done*. This is very important, but it is even more important to know *what we can do* in the future. In other words, the gift of prophecy is often more valuable than the knowledge of history. Therefore the chief object of putting history into this form is to make it effective for prophecy — that is, for determining the cost of new product, estimating the cost of new work, and directing the expansion of business along the most profitable channels. And beyond that, figures of cost intelligently prepared and analyzed serve as true guides showing exactly where our losses, wastes, and inefficiencies occur, revealing changes or irregularities requiring investigation, and calling as loudly as figures can call for the reforms and economies that will make our output larger, better, or lower in cost of production. The real purpose of cost finding is cost reduction.

LABOR. THE PRIMARY WAGE SYSTEMS

CHAPTER VII

LABOR. THE PRIMARY WAGE SYSTEMS

LABOR represents the most interesting, the most difficult, and probably the best studied part of works management — and yet the part which is furthest from finality. This is because it has to deal not with a passive "party of the second part," such as we have to consider in material and machinery, but with human ambitions, hopes, fears, and prejudices — in short, with "the other fellow." Until the race reaches the end of its evolution we shall never reach the end of the labor problem.

Labor may of itself be the largest element entering into manufacturing costs, and therefore may deserve *per se* the largest measure of attention because of its intrinsic importance; but even when it is relatively one of the smaller factors in the equation, it may have immense potentiality in affecting the values of the others which appear intrinsically larger. It may, so to speak, be not a separate quantity in the equation, prefixed by a *plus* or *minus* sign, but a co-efficient or even an exponent, affecting the value of an intrinsically much larger quantity. A man whose wages are 30 cents an hour may control the operation of a machine which, for interest on its first cost, maintenance, depreciation, floor space, and stand-by losses, represents a fixed charge of $3 an hour. If the man is slow in his movements, and takes an hour and a half to do a job which he should finish in an hour, the important loss is not the 15 cents in wages for the man's time, but the $1.50 for the machine's time. If his work is badly laid out so that he waits 15 minutes between jobs, the important loss is not the 7½ cents paid him for his time of idleness, but the 75 cents loss through the idleness of the machine. Or, again, the $3 a day man may work half a day on a piece worth $15 and by carelessness or incompetency may spoil the job. The important loss is not the $1.50 paid in wages for which we get no return, but the $15 for the material destroyed. In many classes of manufacture the investment in general plant and mechanical equipment, and the fixed charges for power and transmission, maintenance, superintendence, management, etc., make what is called the "overhead burden" a larger tax than the payroll; in such a case it may be a wise policy to stimulate production by an increase in wages more than proportionate to the increase of output, because we shall recoup our extra wages expense by the reduction of the burden resting upon each unit or product. To be more specific: Suppose we are turning out 100 machines a day, our daily labor bill being $500, the cost of our material another $500, and our general expense $1,500 per day. The cost of each machine is then 500 *plus* 500 *plus* $1,500, divided by 100, equals $25. Suppose next, by doubling their wages we can spur our men on to such zeal that they turn out 150 machines a day. We are paying 100 per cent more for labor and getting only 50 per cent more product. Nevertheless, our total cost of $1,000 for labor, $750 for material, *plus* $1,500 for fixed expense, equals but $3,250, and when this is divided up among 150 machines the cost of each is shown to be only $21.67. We have reduced our total manufacturing cost $3.33 on each unit, or about 12½ per cent. And, in addition, by the increased output we have secured another advantage; that is, the more rapid turnover of our invested capital.

The general principle involved is this: Material cost and labor cost per unit of product naturally vary directly with the number of units we manufacture; but expense costs are, in a very large proportion at least, invariable. They remain just the same whether the amount of product we turn out is large or small. If we turn out but few units the expense cost of each, therefore, becomes great. If we turn out a great many units the expense cost of each becomes very small. We can therefore often, and indeed almost always, well afford to increase the *wages cost* per unit, if by so doing we can stimulate the workers to turn out a large volume of work and so cut down the *expense cost* per unit. The saving in expense cost compensates the manufacturer for the increase of wages cost. The increase of wages compensates the workman for his extra effort. This is the fundamental idea underlying the advanced wage systems. It is quite simple, but failure to understand it and realize its importance has been the cause of most of the resistance to the introduction of these systems and to many of the labor troubles between employers and employees.

At the root of the whole thing, as already pointed out, is the fact that the enormous expansion of the manufacturing system made it difficult to maintain individual relations between the employer and the individual workman. The conditions were defined somewhat fully in the second chapter but the argument may be summarized again here. There was first the mere difficulty of numbers — the collection of hundreds and thousands of men in one establishment or one organization; the identity of the workman and the efficiency of his work was lost sight of in the crowd. There was next the tendency to specialization, under which the individual worker seldom turns out any complete article, but only performs some part of the process or operation, passing the work on then to the next specialist, who performs the next operation, so that it becomes still more difficult to pick out and identify the work of any one man. Thirdly, there is the tendency to standardization, under which the individual worker does not put much of his own thought or his own skill into the job, but simply repeats mechanically a routine marked out by the patterns or the more or less automatic machines and the detailed instructions provided for him by the thought of somebody else. The almost overpowering influence of these tendencies is to weld workmen into classes and to substitute dealing with a class for dealing with an individual. And when this happens without the balancing influence of any other principle, the next inevitable step is that the inducement to individual efficiency disappears. Under ordinary conditions it is a very small and very uncertain profit for a workman at the bench, in the ditch, on the wall, to work harder and better than his fellows. He is not noticed and he gets no reward. Therefore, as Mr. Gantt has so ably pointed out,[1] the next necessary consequence is that the man of more than usual ability, finding that he can not make anything by putting that ability into his work, turns his ability to agitation. He sees that he is treated as a member of a class and can get no more than the ruling wages paid to that class; so he endeavors to enlist the whole class in getting those ruling wages raised. Trade unions have been occupied chiefly with efforts to raise wages or to shorten hours because it was only by united action that the individuals composing the union could get more. If the scheme of employment and payment for work done were so adjusted that a good worker would automatically be singled out, rated according to his performance, and paid according to his ability, the energetic workers would be much less interested in strikes for higher wages regardless of efficiency. The trade unions would not go out of existence by any means, but they would find other and, as it would eventually prove, economically better matters to which to turn their attention.

The advanced wage systems are all efforts, earnest and conscientious efforts, to provide a natural and automatic means for paying the able workman in accordance with his

[1] Work, Wages and Profits. *The Engineering Magazine.*

ability, while they protect the less efficient workman in at least the standard wages of his class. That is, they do not undertake altogether to break up the class system, but to enable any man who is superior to the average to rise above it. They are all based upon some sort of a combination of two elementary ideas of paying men for services rendered. These two ideas are day pay and piece rate. Fundamentally, these are the only two methods of wage payment.

Under day pay a man is paid for the length of time he works, regardless of the amount of work he may do during that time.

Under piece rates the man is paid for the amount of work he does, regardless of the time it takes him to do it.

If I hire a man to shovel sand at $1.50 for ten hours, that is day pay. If I hire him to put a load of coal into my cellar at 15 cents a ton, that is piece rate. If I hire a stone mason at $4 a day for eight hours, that is day pay. If I agree with him to build me a wall at $1.25 a perch, that is piece rate. Under the one system you pay a man according to the length of time he is in your employment, and under the other system you pay according to the amount he does for you. In the bonus system, the premium system, the efficiency system, and all the others which we shall shortly take up in detail, these two elementary ideas are somehow blended; but blending ideas is something like blending colors; the result is not like either of the elementary colors you started with, and mixtures of the same two colors in different proportions are unlike one another. So each of the various wage systems has its own individual color, so to speak; and as certain colors are pleasing to some eyes and other colors pleasing to other eyes, so certain wage systems are pleasing to certain minds and others more pleasing to other minds.

Let us now take up the several wage systems in order, beginning with that which is probably the oldest, if indeed it was not originally the only, method of paying for labor. This is the method of day pay. It is indeed so old and so deep-rooted that one is almost tempted to say that if we go back to the source of things it is the *only* wage method; for when piece rates are fixed you will always find that, consciously or unconsciously, the employer and the workman both compare in their minds the piece rate proposed with the time they think the job is going to take, so that it seems to come down, after all, to the question not what is the *job* worth, but what is the *time that it takes to do the job* worth?

Now the conception underlying day pay is that a certain sum of money is arithmetically equal to a certain number of hours spent by a man — any man — at doing a certain kind of work. For example, every man digging dirt is worth \$1.50 for ten hours' labor; every man laying brick is worth \$5 for eight hours' labor. Stated this way, baldly and without qualification, the notion seems so foolish that it is hard to see how it ever became so generally adopted in practice. It would be as intelligent to base an economic system on the hypothesis that a string is always 6 feet long or that all horses run equally fast. Nevertheless, the conception persists, and will long continue to persist, and you will have to deal with it. It is in the moral code of many labor unions as the first and great commandment. The reason, as already suggested, is that the unions have found it necessary to resort to collective bargaining and to demand a universal wage rate, chiefly because there has been in general no method practiced by employers for fair and honest individual bargaining with each man according to his ability. The result of the whole thing is a struggle between opposing forces, the employer trying to push the day wage down because he has no satisfactory assurance of anything but minimum efficiency on the part of his workmen, and therefore he wants to pay the minimum price; and the men trying to force the rate up because they can not get it up in any way except by force. This sort of struggle is constantly going on, with variable results. Where labor is abundant or poorly organized, and where the employer or sub-bosses have a genius for driving, probably as highly efficient results are secured under the day-wage plan as under any other; that is, the employer gets as high a product for the dollar he expends as he can get by any method. Where labor is powerful and well organized and much in demand, the results secured under the day-wage system are perhaps as inefficient, and as little return is obtained for each dollar expended, as in any application of capital to productive or constructive work, except, perhaps, in deliberately dishonest political jobs.

Nevertheless, the day wage remains to-day the method of payment for a very large proportion, perhaps a large majority, of all service. I have dwelt strongly upon its unfavorable features, but of course they are to a certain extent, even if imperfectly, remedied in practice. The extremely good man cannot be held down, and he will break through even the dead level of day pay; so the fallacy of assuming that all men are equally worth $1.50 a day is corrected fractionally by picking out here and there a peculiarly able man and making him a job boss or a sub-foreman at $2 or $2.50, while the hopelessly incapable fellow is fired off the job and gets no wages at all. The plan as a whole is one of those rough and ready ones that the world has always used and always will use. And it does express, although it expresses it badly, a certain vital truth; that is, that *time,* after all, is the one supreme value that must be seized and used moment by moment or it is lost forever. If machinery is idle the opportunity may usefully be taken to overhaul and repair it; if material is idle it may be worked over into something else which is active; if dollars are idle they are only dormant and will come to life and into circulation as soon as there is an opportunity. But if hours are idle they are dead and gone forever. This truth of the fundamental value of time is recognized by the day-pay system. You will find the system in use everywhere and you will have to get along with it; nevertheless, in most cases a much more intelligent plan for hiring time than the day-wages plan can be devised and may be applicable.

Perhaps the first deliberate effort in this direction was the establishment of piece rates in place of day pay. By these rates the unit of adjustment as between employer and employee is not so much time spent at labor, but so much work completed. The unit task may be of the most diverse kind in different occupations — a ton of coal mined, a locomotive mile run, a yard of cloth woven, a casting made, a certain area of type set, a face shaved or a head of hair cut. The fundamental idea of day pay is that of mathematical equivalence between money and time; the fundamental idea of piece work is that of mathematical equivalence between money and jobs.

If, for example, I am working as a journeyman hatmaker [1] at day wages, I tacitly accept the truth of the proposition that ten hours of my time are worth, say, $2. That is, I agree with my employer upon the truth of this equation:

(A) 10 hours time=$2.00

I come into the shop at 7, go home at 6, with an hour for lunch. I loaf as much as I dare; the boss watches me and drives me as much as he can, and perhaps in the average I make about one hat a day. Now suppose I go on to piece work. I set in the background the proposition "ten hours equals $2," and base my creed on the tenet that "making one hat equals $2." In other words, my employer and I fix our eyes on a new equation:

(B) Making one hat=$2.00

[1] It is scarcely necessary to say that the supposition is taken at random, for illustration only, and does not in the least reflect actual conditions in the hat-making industry.

The longer I dawdle, the longer it takes me to get that \$2. On the other hand, if I work fast I can perhaps get through by mid-afternoon or even earlier and go fishing. Or if I choose to stay I can begin on another hat. Very possibly by diligence and study I can improve the tools or the operations a little, or I may carry on the making of two hats at once, working on each during necessary pauses for the maturing of processes on the other; and I may soon be turning out three hats in two days or even two hats in one day. The boss will be paying me 50 per cent to 100 per cent more wages in a given time than he did formerly. Yet his hats are costing him no more. Indeed, they are costing him less, for his general expenses for shop rent, light, heat, superintendence (that "overhead burden" of which we have already spoken) are no greater than they were before, and yet he is turning out more hats to absorb these charges. A smaller fraction of this cost, therefore, attaches to each hat.

Now I said that in going on to piece rates the boss and I both set in the background the proposition that ten hours equal \$2. I used those particular words advisedly, because that idea at best is only retired. It is not dismissed. It lurks in the background of our minds persistently. The price of \$2 per hat was fixed as a piece rate not because we really believed it was worth \$2 to make a hat, but because on the average that paid me \$2 for a day's time. In other words, we accepted formula (B) not because we believed in its abstract truth, but because we believed this:

(C) Making one hat=10 hours time.

As soon as (C) proves untrue, (B) no longer follows from (A) and my employer at least loses faith in it. When I begin to get \$3 a day the boss begins to get uneasy, and when I make \$4 a day he is probably certain that something is wrong. He believes no journeyman's time is worth

$4 a day. The fact that he is turning out larger product from his shop in the same time at less cost does not impress him as it should, while the $4 a day to a " $2 man " looks enormous. He begins to believe that he is paying too much for the making of a hat. Probably he decides that if two hats can be made in one day, the making of a hat is not worth more than $1, and he cuts my piece rate in half. I have to work twice as hard as I did before and get no more for it. On the other side, my fellow workmen are displeased. They are contented with the old order and want to work along turning out about one hat a day and getting $2 for the day's time. They say " if you show the boss that two hats can be made in a day, he will think that we are all a worthless lazy lot, and he will want to drive us up to your pitch or get rid of us. You are killing the job." So these two influences combine to discourage me against the great and apparently fortunate incentive which first led me to rejoice in the piece rate and to see so much apparent advantage in it.

Piece-rate payment is an old idea. We find it far back in the history of the guilds, and no doubt it existed centuries before that. Within comparatively recent times, however, it has been brought into new prominence through the earnest efforts of men who saw in it a great light to lighten the way out of the darkness of day wages. It offered an incentive to the worker, a reward proportioned to his skill and industry, an enlarged output induced by this financially-stimulated activity, and the very essential result of increased volume of manufacture with decreased cost of product from the same plant investment. Results — important results — have been secured; but yet they have frequently been disappointingly below expectations, chiefly for the reasons suggested in my little parable of the hat-maker.

The great inherent trouble is the difficulty (under ordinary or non-scientific management) of fixing piece prices which are fair and which continue to be fair. The reserve capacity which a workman may be holding back, consciously or unconsciously, in an operation that has not been scientifically studied and standardized, is almost unforetellable. When it is realized under the incentive of piece payment, and his earnings rise enormously, the disposition of the wage payer to rebel against the outlay and to cut down the piece price is almost irresistible. If the employer sees that a workman can do several times as much as he was doing under day wages, you can hardly blame him for feeling that he has been defrauded all along under the old system, and for trying to make things more even from his point of view. But the price-cutting that has so very, very often followed soon after unscientific price-setting has worked immense mischief, by raising in the minds of the men suspicion and distrust of systems introduced to replace the old day-wage plan. Union opposition has been strong against piece rates, and while it has been modified in many places so as to admit piece work, this acceptance has often been accompanied by counter-restrictions which nullify most of the possible advantage — as, for example, the fixation of a very moderate number of pieces as the maximum that any man may make in a day, thereby coming back substantially to day wages.

The trouble here, however, is not so much one of principle as one of administration; but there *is* a fault of principle inherent in piece rates, and that is that they put all the uncertainties of production on the workmen. Suppose a man is machining steel castings at so much per piece. He may have delivered to him a lot of hard metal parts that take four or five times the expected time to finish. For that period, at least, he can not make living wages. Suppose a gang is unloading coal cars at so much per ton, and the switching crew is tardy in moving away empties and setting in loaded cars, and so keeps them idle for considerable periods, or suppose that in setting in the new cars it places them badly so that the men have an extra long throw and work at a disadvantage. Again, the workmen may be unable to make fair wages, through no fault of their own. Suppose, once more, a working gang is made up by the foreman so that green men are mixed with skilled, and these green men by their awkwardness cut down the output of the whole gang. Here, again, if they are working at piece rates, their earnings are reduced without their fault.

In all such cases, unless there is special intervention by someone in authority to make up the loss, it falls upon the piece-rate worker. Under day pay, of course, it would be the employer who would suffer in such cases; but the employer is in the first place better able to stand the loss. The unprofitable item of work is probably only one of many he has in hand, while to the workman it is the worker's entire interest; and last, and most important, the whole power to remove the conditions that caused the loss rested with the employer and not with the workman.

Notwithstanding these certain defects of principle and administration, however, piece rates are a good deal used. Where the rates are carefully and fairly set, by fair and frank effort on the part of both employer and employee to make them right, and where they are fairly maintained after they have been set, they are often (almost usually) preferred by the men; for they make the man more the master of his own time, and they enable the capable workman to increase his earnings in correspondence with his ability and capacity. Where the men will work fairly under the piece rates they are liked by employers also because the system stimulates larger production from the same plant without materially increasing the indirect operating expenses. These are the advantages of the piece-rate system — increased output and increased earnings. Its disadvantages are that when difficulties interfere with output the men's loss is not made up to them without special action by the employer;[1] and, worst of all, that when the employees' earnings are very much increased the employer can seldom resist the temptation to cut the rate. Knowing this, the men are frequently suspicious and seldom let themselves out to anything like their real capacity.

The "contract plan" of employing and paying labor is used to some extent, especially in heavy machine-shops, that is, locomotive and shipbuilding plants, in the United States and Great Britain. It is not, however, a separate and distinct system, but is substantially a gang piece rate. An over-all price for a job is agreed upon with the contractor, who uses the equipment and facilities of the employing shop, but hires his own workers and assistants on terms arranged between him and them. As discipline and responsibility thus fall chiefly on the contractor, while the tools, facilities and general environment are largely supplied by the shop, the plan leads to a somewhat demoralizing divorce of authority and liability. It is likely to lead, and in practice it does lead, to very bad industrial conditions. Nevertheless, it has been in use for a long time, and remains in use, and hence must be considered a practical and to an extent commercially successful method, although the success is not determined by very high standards.

And now, having noted the principle characteristics of the two fundamental methods of wage payment — day pay and piece pay — we come to the systems which I have called "advanced"; that is, the special systems designed to correct or to reduce greatly the evils of the straight day wage and the straight piece rate. The principal of these are the Halsey premium plan, the Taylor differential piece rate, the Gantt bonus system, and the Emerson efficiency or in-

[1] The objection is inseparable from the straight piece-rate system. It is, however, removed by the "piece-rate with guaranteed day wages," which is becoming well-known, especially in railway shops.

dividual-effort system. They are placed in this order for reasons that will appear as we go on. And the Halsey premium plan is placed first because it is simply and only a wage system, while the others are rather parts of philosophies and methods of handling labor in which the wage system is only one element.

The Halsey premium plan [1] bears the strong impress of intimate familiarity with the shop — of complete knowledge of the traditions of the shop, the suspicions of the shop men, and the weaknesses of shop managers; and it seems to be marked further by a conviction of the strength of these long-established institutions and by a tenderness toward disturbing or offending them. It is, in short, a characteristically well-informed effort to get good results, to bring about better conditions, without making any trouble.

The essence of the Halsey premium system is to pay men the established day wage under any circumstances, and then to reward them further by a voluntary extra payment if they do better than the established record of past performances. When the system is introduced there is no necessary or conspicuous change from the way things have always been done. Every man gets his regular day wages on pay day exactly as before. But by reference to past records, standard times are set for the various operations upon which the workmen are engaged. In setting these standard times some allowance may be made for the probable shortening of the old records under the incentive the premium system is going to offer; but in the main the controlling consideration is, how long did the job take on the average when it was done by good workmen in the past? These standard times are tabulated, recorded in the office for reference, and the times taken by the men day by day in doing

[1] "The Premium Plan of Paying for Labor," by F. A. Halsey; Trans. Am. Soc. M. E., June, 1891.

these same jobs, or performing the same operations, are compared with these standards. When any man shortens the standard time on any job after the plan has been put in force, he is credited with a premium, which is equal to his wages at his regular hourly rate for a portion of the time he saved on the job. This portion is usually either 30 or 50 per cent of the time saved. The idea of granting only part of the saved time to the workman is twofold. First, he uses the shop facilities harder — uses more power, wears out more tools, etc., and so the shop should have part of the gain; second, as the employer thus profits as well as the man, he is less likely to be tempted to cut rates when the time is a good deal shortened.

Premium earnings are kept separate or may be kept separate from the regular payroll and enclosed in separate pay envelopes. Their acceptance by the men is wholly voluntary. The workman can take his premium or leave it; but he usually takes it — if not at first — when the accumulation begins to look tempting. It is, however, plain that the introduction of the system raises no issue which could well be a basis of a strike, as the introduction of piece rates into the day-work shop might do. It does not abolish old conditions and introduce new ones, which must be accepted whether they are liked or not. It simply offers a new, non-compulsory opportunity for the men to earn more money if they choose, without any arbitrary or even necessary imposition of a forced rate of working. Furthermore, the calculation of the premium is the simplest sort of a sum in elementary arithmetic. The standard times are posted. The workman can keep a record of his own times. All he has to do is to find by subtraction how much time he has saved, take one-half of it or 30 per cent of it, as the case may be, and he knows his own premium at once. On account of its simplicity and its conciliatory characteristics, probably, the Halsey premium plan is in use in a larger number of shops than any other of the advanced wage systems.

Halsey puts no upper limit on a workman's earnings. However much the man's skill and ingenuity may shorten the times he gets his regular proportion of the gain. One objection sometimes raised to the plan is that as the times are not scientifically set (that is, as the operations are not scientifically studied and figured down to the shortest practicable time), they may sometimes prove to be very much in error against the shop, and the discovery that they are and that the men in consequence are making very high premiums may tempt the employer to cut them down, something in the same way as piece rates are so often cut down.

James Rowan, a member of a prominent firm of engine builders in Glasgow, has put forth a modification of the premium plan, generally known as the Rowan premium, which has as one of its principal objects the protection of the shop against such mistakes as are referred to in the preceding paragraph. The fundamental principle of the Rowan premium plan is that under no circumstances can the workman make more than double his regular day wages. Under the Rowan system the time saved is converted into a percentage of the standard time. The workman then receives, as a premium, this same percentage of the time he actually took. Another way of defining the Rowan premium takes the form of the equation:

$$\frac{\text{Time saved}}{\text{Time set}} \times \text{Time taken} = \text{Premium.}$$

The system is regarded with a good deal of favor in England, but it is not much used in the United States. It pays the workman more largely than the Halsey plan for the earlier (and easier) savings, but as the base upon which the premium is calculated shrinks constantly as time is saved, the man's profit from large savings of time decreases proportionately. The actual premium is the same at 90 per cent time saved as at 10 per cent. There are some other special modifications of the premium plan in use, but it is not important to include them here.

LABOR. PHILOSOPHIES OF MANAGEMENT

CHAPTER VIII

LABOR. PHILOSOPHIES OF MANAGEMENT

PROCEEDING now from the wage systems which are merely modes of payment — that is, which do not go beyond the concept of enlisting the workman's interest through the medium of his compensation — we come to another group of methods in which the manner of payment is only one feature of a policy of management, embodying many other ideas and principles.

Prominent among these as one of the early and very widely noticed applications of the ideas upon which other systems of very different philosophy have been built, is the Taylor differential piece rate.[1] More than thirty years ago, at the Bethlehem Steel Works, Frederick W. Taylor began a development of the conception that labor of all kinds, operations of all kinds, could be scientifically studied and analyzed and reduced to elementary processes; that these elementary processes could each be performed in some one best way, discoverable by an expert investigator; that there was a minimum of time in which each could be continuously performed by a good workman; that the workman could be taught to do each elementary operation, and hence the entire job, in the best way and the minimum time; and that the payment of a considerably larger price for work done according to the standard than for work that failed to reach the standard would secure the co-operation of the employee and induce him to put forth his best effort.

The Taylor system is no longer followed at South

[1] "A Piece-Rate System," by Fred W. Taylor; Trans. Am. Soc. M. E., June, 1895.

Bethlehem but its data are so important on account of the influence they have exerted on later practitioners that they deserve more careful attention than the number of actual instances of the use of the system would seem to suggest.

Taylor begins, then, by an ultimate analysis of the job into its elements. Each of these elements is then subjected to thorough expert study to determine the methods and appliances by which a man working steadily at a pace he can maintain without injury can reach maximum performance and minimum time. The workman is then provided with everything necessary to accomplish, in the standard time, the results determined by this study, and he is thoroughly instructed in every step of the operation by minutely detailed written schedules and by expert advisers.

Finally, he is paid at piece rates which are set at two different levels — a low price per piece if the workman fails to do the job in the standard time, and a high price per piece if he does it in the standard time. This is the so-called differential rate. The successful worker is paid not only for the more pieces he turns out, but he is also paid more for each piece. The unsuccessful worker not only makes less pieces to be paid for, but is paid less for each piece of the smaller number he makes. The money gain to the man who attains standard performance thus becomes very large.

For example, suppose a standard performance for a certain repetitive job is set at ten pieces completed per day. The piece rate may then be fixed at 30 cents each if standard time is attained and only 25 cents a piece if it is not. The workman who finishes only nine pieces in a day receives but 25 cents each, or a total of $2.25. The workman who finishes the ten pieces set as a standard receives 30 cents each or a total of $3. For an increase of only 11 per cent in production he gains an increase of 33 1-3 per cent in wages. This large incentive is provided to enlist the co-operation of the workman — to make him contribute his part to the effort which was begun by the management in their study of conditions and their provision of the equipment and the instruction which would enable the man to turn out a large volume of product. Under the Taylor system, however, it is not intended to leave within the workman's power much more than this co-operation. That is, it is not intended to rely upon the workman to originate betterments in practice, at least until he has accepted all the betterments contemplated by the investigators and instructors. This is a sharp distinction from the Halsey system. Halsey relies almost entirely upon the workman's knowledge of his job, the workman's intimate acquaintance with shop conditions, tools and the details of the operation to perform this operation better and more quickly when the incentive of additional pay is provided. Taylor, by a minute time study and a carefully elaborated scheme of operations, manipulations and methods, purposes to supersede the workman's knowledge — to cancel, as it were, the workman's personal equation. In principle, there is no objection to the workman turning out as large an excess over the standard output as he can. In practice it is not intended to leave him any large margin of capacity for doing better than the standard. And, like the ordinary piece rate, if a man does not reach standard his wages drop. There is no minimum wage assured.

The bonus plan worked out by H. L. Gantt,[1] an associate of Mr. Taylor, has rather more elasticity and has found highly successful application. Like Taylor, Gantt begins with standardization of conditions and accurate time study. That is, he makes it possible for the man to work fast, and decides as nearly as possible just how fast the man

[1] "Task and Bonus," by H. L. Gantt; Trans. Am. Soc. M. E., 1901. For a much fuller argument see "Work, Wages and Profits," by H. L. Gantt; *The Engineering Magazine.*

should work. The initial engagement of the workman, however, is on a day-pay basis. The workman is sure of regular day wages as a minimum.[1] Under the Taylor piece rate, or any piece rate, the minimum as well as the maximum depends on the number of pieces made. If a man is unlucky and does not finish even one piece he gets nothing. Under the Gantt system he gets day wages however little he may produce. The computations for extra or bonus payment thereafter are on the basis of time. To use Mr. Gantt's own words:

" Under this system each man has his work assigned to him in the form of a task to be done, by a prescribed method, with definite appliances, and to be completed within a certain time. The task is based on a detailed investigation by a trained expert of the best method of doing the work; and the task setter, or his assistant, acts as an instructor to teach the workmen to do the work in the manner and time specified. If the work is done within the time allowed by the expert, and is up to the standard for quality, the workman receives extra compensation (usually 20 to 50 per cent of the time allowed) in addition to his day's pay. If it is not done in the time set, or is not up to the standard for quality, the workman receives his day's pay only.

"The system is thus in effect a combination of the day-rate and piece-work systems. While learning to do his task the workman is on a day rate; when he has learned to do it the compensation for the task is a fixed quantity, really equivalent to piece rate. The method of payment, then, is day rate for the unskilled and piece work for the skilled."

The Gantt system produces the true piece-rate result that a workman receives full pay at the bonus rate for all the

[1] This seems much like the " piece rate with guaranteed day wages," referred to in a preceding note. One difference is that if the " task " is changed, it is a change of *time* and not an immediate change of *price,* and the effect on the men is much more favorable.

time he saves. He does not divide the time saved with the shop as he does under the premium plan.

Gantt, like Halsey, puts no limitations — that is, no arbitrary, or, as we might say, official limitation — on the amount a man may earn. He does not set any maximum, as Rowan does, on the theory that a workman should not be permitted to make more than a certain scale of wages. But Gantt does in substance set a natural limit to maximum earnings by putting the task limit so high that even the most skillful and energetic man could not greatly exceed it. He does this deliberately, because in the first place, when conditions are scientifically adjusted to eliminate the ordinary chances and mischances of haphazard working, and when operations are scientifically laid out and the time it takes to do them is scientifically studied, and when men are carefully instructed in performing the operations in the manner thus scientifically studied out, the performances of normally capable individuals ought not to and will not vary very widely from the determined standard.

For instance, if 100 men of average physique, taken at random, were required to run 100 yards in their ordinary clothing and under ordinary conditions of preparation and amid ordinary surroundings of street travel, the results would probably vary by many hundred per cent, because not only of the varying fitness of the men, but of the varying obstacles and delays they would meet. But if you should take the same hundred men, train them for six months, put them on a standard running track, in regular running costume, you would probably find that most of them would do the hundred yards in times varying not more than 50 per cent and probably not more than 20 per cent. This is the kind of standardizing Gantt's preparatory measures are designed to accomplish.

And in the second place, it is part of Gantt's theory that no large reserve capacity (that is, capacity of surpassing standard task) should be left to the workman, for fear that if he does very greatly better the prescribed performance, and so very greatly increase his earnings, the employer will be tempted to cut wages and so will destroy the whole scheme. This danger is avoided if the bonus task is set so high that no workman unless he is a living phenomenon can better it by at the utmost 50 per cent.

Like the differential piece rate, the Gantt bonus system is characterized by a sort of critical point at which the wages received by the worker rise suddenly on arrival at a certain volume of production. The effect of the Gantt bonus as a stimulus to the workman is something like that of offering a big, shining prize to every man who jumps up a high step. The prize seeker either lands or he fails. There is no half success possible. The total result of such a tournament, if there are entries enough, would be the collection of an athletic body of high jumpers on the upper step, while the field would be left below.

Applying the same simile to the Halsey premium plan, we might say that it offers the workers on the lower level an inclined plane up which to climb, with prizes for every one who climbs at all, infinitesimally graduated in direct proportion to the distance climbed. The natural result of such a tournament is a graded classification of moderate athletes, whose performances range all the way from the record holder to the tail ender. And there is also a natural tendency for the crowd to thin out toward the upper levels, because as a man climbs each step becomes harder, and yet the premium for the last step is no greater than the premium for the first.

The illustration just used is not intended to suggest the slightest disparagement of either the theory or practice of the task and bonus system. Under Gantt's direction of it, the most careful, thoughtful, and skillful instruction and assistance toward accomplishing the task is given to the operative. To the utmost possible degree, all obstacles to achievement are removed. Those who can not succeed at one task are given every opportunity to try some other for which perhaps they may be better fitted. Those who do succeed are unquestionably greatly benefited, both physically and financially. Nevertheless, for any given work the system is largely selective, discovering the fully fit (who are generally a minority) and shifting the unfit (who are generally a majority) to other occupations.

Because Halsey and Gantt both grant day wages as a minimum and add something more if a man exceeds standard performance, there is an unfortunately general but ill-informed impression that the systems are much alike. Psychologically — that is, in their interpretation of and appeal to human emotions — they are almost diametrically unlike. They seek similar results (an increase of production) and they offer a similar reward (pay for time saved) but by contradictory policies. Halsey is so desirous not to "stir up things" that he scarcely lets the men know that times are being studied. Gantt is so desirous to make large output possible that he would make most radical and far-reaching changes if necessary to remove causes of inefficiency. Halsey relies entirely on the workman's ability to find ways of shortening the standard time. Gantt analyzes each job scientifically, resolves it into its elements, determines the best way and the minimum time for performing each, and will not even let a workman try to earn bonus until the man has been thoroughly instructed by an expert. Halsey abhors the idea of setting any "task" as the limit a man must reach. Gantt glories in the "task" as a stimulus to effort, and makes such a task the goal a man must reach before bonus begins. Halsey tempts the man on by at least a small premium for even a trifling gain in the time used. Gantt gives no bonus until the very large gain necessary to reach his task limit has been made, and then he gives a great big bonus — 25 per cent or 50 per cent all at once.

Halsey avoids class distinctions by making the passage from day-wage earnings only to premium earnings a progress of insensible gradations. Gantt emphasizes class distinction not only by the sharp and wide break between day wages and bonus earning, but also by encouraging outward signs and symbols of bonus earning — encouraging the group of bonus workers and the creation of a bonus society, entry into which is a desirable goal for those who are still in the no-bonus class.

These things are really more important in dealing with men than questions of 20 per cent, or 30 per cent, or 50 per cent premium; and in these things the philosophies of Gantt and Halsey take widely different and opposing views.

The Emerson efficiency or individual-effort system [1] has certain resemblances to both the Halsey premium and the Gantt bonus plans. It recognizes that there is truth in the psychology of both these systems, different as they are psychologically, and it recognizes advantages in both their methods. Nevertheless, although it has these resemblances it proceeds by a philosophy and a plan of its own, which is distinct and characteristic.

To begin with, it establishes the regular daily-wage scale and system as the basis of employment, thus agreeing with both Halsey and Gantt. Next, it prescribes the standard of production after scientific study, and offers a rather large bonus for reaching it, thus agreeing with Gantt; but it leads up to this bonus reward by a graduated scale of smaller bonuses, thus approaching the Halsey premium plan.

To take up its features in greater detail, let us go back to the measures preliminary to the introduction of the sys-

[1] "A Rational Basis for Wages," by Harrington Emerson; Trans. Am. Soc. M. E., June, 1904. Also "Efficiency as a Basis for Operation and Wages"; *The Engineering Magazine*.

tem. As in the case of the Taylor and Gantt policies already described, the arrangement, equipment, and working conditions in the shop or factory are standardized to secure the utmost efficiency and to prevent all wastes and losses that are preventable. Standard times for every operation are then determined and scheduled by the most careful study. In setting these times Emerson apparently gives more weight to averaged past experience than Taylor or Gantt, but is not so closely governed by it as Halsey. Taylor and Gantt, indeed, are inclined to proceed without much regard to what has been the practice in any particular case. They go back to the very best way of doing the thing, and having determined this scientifically for every element, they add these elementary operation times together, allow a certain factor for what might be called the human equation — that is, a margin by which the workman may be permitted to fall short of perfection — add perhaps another factor for imperfection of materials, and so arrive at a final result. Halsey is disposed to make good existing shop practice the standard and not to go very far back of that in setting standard times, but to rely largely on the skill and effort of the individual workman for finding ways of bettering the old records. Emerson's policy inclines rather to the method of taking such records as Halsey would accept as standards, and refining down by deducting for the preventable wastes and losses that have been occurring and that are to be eliminated by the improvements installed. This method, as will be seen, goes upon the supposition that if you take practice as it is, and correct it for all the errors and inefficiencies you can discover and identify, the residue will be automatically self-corrected with such inherent, necessary, and unpreventable inefficiencies and wastes as are innate in conditions and undiscoverable by inspection.

Under the efficiency system, if a workman finishes a job or an operation in the standard time which has been fixed, he receives a bonus of 20 per cent. This rate is about the same as the lower limit usually adopted by Gantt. The Emerson bonus for standard performance, however, is always 20 per cent, while Gantt varies somewhat with the agreeableness or disagreeableness of the work, occasionally running as high as 50 per cent and probably averaging from 30 to 40. Under the efficiency plan, however, if the workman reaches *two-thirds* of the standard performance (that is, if he finishes the job in one and a half times the standard time) he reaches a point beyond which he begins to receive a little extra reward, increasing gradually like the Halsey premium. This reward, however, instead of rising at a uniform rate as the Halsey premium does, rises on a sliding scale. It rises, in fact, as a function of a parabola, the performance being measured along the curve and the bonus being apportioned according to the ordinate. This makes the bonus very small indeed for the early savings of time below time and a half. It merges into the 20 per cent bonus at standard performance. For still further reductions of time, that is, for doing the work in less than standard time set, the workman gets the 20 per cent bonus, *plus all* the time that he saves.

In the practical use of the system, the individual bonuses are usually calculated for each man's work for a period of one month. His efficiency for that entire time is reduced to a percentage by dividing the times allowed by the times taken. For instance, taking a single job as an example, if a man takes 90 minutes to do a job standardized at 60 minutes, his efficiency is 60 divided by 90, or 66 2-3 per cent. If he takes 60 minutes to do a job standardized at 60 minutes his efficiency is 60 divided by 60, or 100 per cent. If he takes only 40 minutes to do a job standardized at 60, his efficiency is 60 divided by 40, or 150 per cent. As already explained, however, it is characteristic of the Emerson efficiency system that the efficiency is not calculated job by job, but on the sum of all the work done during the bonus period, which, as already explained, is usually one month. Two important results are thus secured. The first is that elaborately accurate timekeeping is not necessary for wage purposes, although quite apart from this it may be desired for cost-keeping purposes. All the paymaster needs is a list of the jobs each man did during the bonus period. He takes off, from the standardized schedule of operations, the standard times allowed for these jobs, adds them together, and divides these total standard hours by the total of the wage hours the man actually worked. The result gives him the man's efficiency percentage for bonus calculation. He looks in his standard table for the bonus corresponding to that efficiency and adds it to the man's regular wages. The first result, then, is that minute time-taking is not essential. The second result is that unless a man maintains good efficiency on all jobs his bonus is automatically cut down. Suppose, working repetitively at a job standardized at 60 minutes, a man should spurt for two hours at a 40-minute gait, and then should loaf for eight hours at a 120-minute gait, he would finish in 600 minutes only seven jobs standardized in total at 420 minutes. His efficiency would be 420 divided by 600, or 70 per cent. His bonus would practically disappear. He would still get his day wages, of course, just as he would under the Gantt plan or the Halsey plan; but under the Halsey premium he *would*, and under the Gantt system he *might*, be awarded bonus for the three quick jobs, although on the whole he was not a profitable man to the shop. It is not uncommon, where the premium system is in force, for men to beat the shop in this way by earning a good premium through an energetic spurt and then loafing along at day wages for some time afterwards. This disposition is automatically met by the efficiency plan. Gantt provides for it to a considerable extent by offering a secondary bonus;

for example, a bonus to the foreman if every man under him makes bonus, or a second bonus to the worker who makes bonus every day in the week.

A peculiar point in the efficiency system is that the bonus begins at 66 2-3 per cent efficiency. The awards for the earlier and easier savings of time, however, are very small. At 67 per cent efficiency the bonus is 1-100 of 1 per cent of a man's wages. It does not become 1 per cent of his wages until he reaches 74 per cent efficiency. At 77 per cent efficiency the bonus is 2 per cent of wages; at 83 per cent it is 5 per cent of his wages; at 90 per cent efficiency, 10 per cent of wages; and at 100 per cent efficiency, 20 per cent of wages. The full table is given below:

Efficiency per cent.	Bonus per $1.00 wages.	Efficiency per cent.	Bonus per $1.00 wages.	Efficiency per cent.	Bonus per $1.00 wages.	Efficiency per cent.	Bonus per $1.00 wages.
67	.0001	78	.0238	88	.0832	99	.1881
68	.0004	79	.0280	89	.0911	100	.20
69	.0011	80	.0327	90	.0991	101	.21
70	.0022	81	.0378	91	.1074	102	.22
71	.0037	82	.0433	92	.1162	103	.23
72	.0055	83	.0492	93	.1256	105	.25
73	.0076	84	.0553	94	.1352	110	.30
74	.0102	85	.0617	95	.1453	120	.40
75	.0131	86	.0684	96	.1557	130	.50
76	.0164	87	.0756	97	.1662	135	.55
77	.0199	87.5	.0794	98	.1770	140	.60

To go back to a simile already used, if Gantt invites the men to jump and Halsey coaxes them up an inclined plane, we might say that Emerson shapes this plane to a gradually increasing curve. Each man's performance is measured by the distance he comes along the curve, while his reward is proportioned to the vertical height he climbs. Increasing fatigue is thus met by proportionate reward for each successive effort. The normal result is the training of a number of men with graduated records, as under the Halsey plan, but with a tendency to collect the denser crowd near the top, with the line thinning out as you go down the scale to the smaller and poorer performances.

Omitting minor variations which are of limited interest, the systems we have now reviewed comprise all the well recognized and distinctly formulated wage systems properly speaking. There are, however, certain other policies of handling labor without particular stress on the method of paying wages which have many strong and interesting characteristics and are worthy of notice, even in an elementary review.

The first of these is connected with the name of Frank B. Gilbreth,[1] a disciple and adherent of the Taylor doctrine, whose methods have been developed and applied chiefly in connection with building and general contracting. Gilbreth maintains that not even "time study" is the limit of elementary scientific analysis — that back of that is "motion study." His best known work has been in the simplification of building operations by very skillful and very interesting eliminations of traditional but needless wastes of effort or method. His practice in handling labor is characterized by four major principles: First, the separation of the work so that, as far as can possibly be managed, each man works separately and individually — that is, so that his separate individual performance can be distinguished and measured. Second, constant observation by a sufficient force of timekeepers to record individual performance from hour to hour. Third, conspicuous and immediate posting of these records so that comparison between man and man, or, if unavoidable, between gang and gang, can be made every shift, if not indeed every hour. Fourth, reward of

[1] His principal publications descriptive of his methods are "Brick-Laying System," Myron C. Clark; "Field System," the same; "Motion Study," D. Van Nostrand Co.

some kind (and experience shows that it may be of the most varied kind so long as it is positive and conspicuous) for the best performance or performers, and admonition for the poorest. In brief, it depends largely upon the stimulus of emulation, of competition, and it consists essentially in providing conditions under which emulation can work most actively and in providing prizes, either substantial or sentimental, to be competed for.

The next to be mentioned is the policy or method connected with the name of Charles U. Carpenter,[1] which has the following characteristics: First, great emphasis is laid upon a committee system, by which officials responsible for the prosecution of the work are brought into frequent meetings to report upon existing conditions and to furnish estimates or commit themselves to agreement as to what can be accomplished in the immediate future. Second, an immediate record is made of these reports and undertakings, usually on a blackboard, so that the official goes down in black and white before his fellows, and knows that the record will confront him at the next meeting. Third, this system of conference and consultation, with some attendant emulation, is carried down even to assistant foremen and job bosses. Fourth, a system of individual reward by a slight increase of wages or small promotion is used to encourage and distinguish the man who strives for and attains more than ordinary efficiency.

Neither of these systems is as automatic in its action as the wage systems previously described, but both aim at the same purpose, which runs through all the methods considered — the restoration of individuality to the workman, who has been so largely unindividualized by the major tendencies of the modern industrial system.

Profit-sharing is frequently spoken or thought of as if

[1] For a full exposition, see his book "Profit Making in Shop and Factory Management," *The Engineering Magazine.*

it were some sort of wage system, and is mistakenly classed with premium and bonus plans.

It is not naturally related to these systems, either in method of administration or in philosophy. It lacks completely the individualizing action, which, as previously urged, is one of the fundamental qualities of the premium, bonus and efficiency plans generally. By profit-sharing, as the term is now used, is meant the policy of paying to labor, at rather long intervals — usually a year, although sometimes six months or even three months — a dividend related in some way to the net profits of the business for the same season. A typical instance in this country is that of the Procter & Gamble Co. Profit-sharing has been in effect in the Ivorydale factories for a good many years, the practice being to pay to a selected class of the workpeople, as a dividend, a percentage of their wages equal to the rate declared on the common stock of the company. The practice is more widely used in England than in the United States, perhaps because the piece-rate, bonus, and premium systems, originating here, anticipated the profit-sharing system, and already occupied the place it might possibly otherwise have taken.

The difference in idea and in operation scarcely needs to be pointed out.

In the wage systems which we have already discussed, the increased earnings are directly proportioned to the increased effort of the workman, and are received promptly in connection with his regular payment for that effort. The connection between extra diligence and extra reward is instant and obvious. If a man works hard he receives all the benefit. If he does not gain any bonus or premium he usually has only himself to blame. In profit-sharing, the dividend comes after the lapse of a long period of time, and the conditions leading up to it are more or less obscure. It depends upon the net earnings of the business, which are affected by many elements, of which labor in total is only one, and the work of any single individual is an extremely small fraction. The man who has worked very hard may be disappointed because losses through bad debts, errors of business judgment, or an unforeseen change in the markets, have cut into the profits of the concern and no net earnings are shown. There is too much bookkeeping between the individual worker and the company's published report, and the man is always inclined to think that accounts are being juggled so as to deprive him of his dividends. Lastly, the extra payment is either divided among all employees, efficient and inefficient alike, or else the employees are graded into classes, not automatically by the inerrant justice of their time and job records, but arbitrarily by the ruling of some superintendent or foreman.

Profit-sharing, therefore, while it is to be respected as an earnest attempt to harmonize labor and capital, is not a very logical or very successful attempt. When all is said and done, it has the air of being a sort of gratuity and it is not properly speaking an advanced method of wage payment. The same thing seems to be true in part of the plan for selling stock of a corporation to the employees which seems to be finding favor nowadays. There is no necessary, automatic, and manifestly just relation between an employee's efficiency or faithfulness and his ability to save money and invest in stocks. The most deserving man in the company's service may have a large family, or a sick wife, or dependent parents, and he may have to turn aside from the opportunity to become an investor and see it go to someone whom he knows (as perhaps only one workman can know another) is less worthy. The plan of course creates a body of employees whose interests are financially interlocked with the interests of the company, and to this extent it tends to " harmonize capital and labor," but this body is necessarily small and is not necessarily formed on logical lines.

Before leaving the subject of labor, it is expedient to say something upon an aspect of the treatment of labor in industrial plants which has recently been advanced prominently into public view. This is what is generally known as betterment or welfare work, and it covers all sorts of institutions for the hygiene, comfort, pleasure and instruction of the workers.[1] These institutions are outside of contract relations between employer and employee, but installed or promoted by the employer with motives in which altruism and enlightened selfishness are compounded in various proportions. Usually it is frankly admitted that the purpose is to provide a healthy physical and moral atmosphere in which the employee may naturally develop his highest efficiency, to make conditions so pleasant that good men will naturally incline to remain permanently in the service rather than to rove, and to establish a feeling of friendliness and good will to which the employee will respond by willing loyalty to his work and his employer.

There is great diversity in opinion as to how far work of this kind may advantageously go. Comparatively few years ago there was generally very great indifference on the part of manufacturers as to the physical well-being of their workpeople, and conditions of light, heat, ventilation and sanitation were often completely ignored. While the newer movement has gone to perhaps extravagant extremes in certain cases, there is no doubt whatever that it has exercised an excellent influence in awakening shop managers to a realization that employees should be surrounded with conditions of ordinary decency and comfort at least, and that the money so expended yields large return in improved output

[1] A very large number of examples are assembled in "Social Engineering," by Dr. W. H. Tolman, McGraw-Hill Book Co.

and quality of work. One of the ablest works managers I ever knew used to say: "We must give the workmen a comfortable shop, well lighted, well ventilated, warmed if necessary to a point comfortable for physical exertion; we must give him a place to change his clothes, to wash with proper regard for his individual self-respect. We must have well kept lavatories and sanitary conveniences. Why — because we love the workman? No, but because, like all other machines, he works best when he is kept in the best condition." This is a very utilitarian statement, and perhaps it expresses the lowest limit to which welfare work should certainly go. It must be admitted that where conditions of peculiar discomfort are attendant upon the work — conditions which the employee alone is unable to remedy — the employer may well go to considerable length in overcoming them or in supplying offsetting comforts. I noticed recently in a trip over the Santa Fe road [1] that reading and recreation rooms at division points, especially across the desert, were throngingly patronized by the men. The outfit was very simple; merely a couple of rooms with plain tables and chairs, the principal monthly and weekly magazines, and dailies from the larger cities along the road; opportunities for playing cards, checkers or other games, and perhaps a piano. At larger points they might have a billiard table or a bowling alley. Unquestionably, in those crude desert towns, devoid of any other wholesome interest, the Santa Fe reading rooms were not only a strong force for law, order, and morality, but also a great advantage in keeping men from that extreme of discontentment which would have made them a fickle and unreliable class of employees in the service of the road.

Beyond this we might go with hesitation. There are, however, a number of companies and corporations which

[1] See "Methods of the Santa Fe," by Charles Buxton Going; *The Engineering Magazine.*

have attracted wide notice by a series of provisions for comfort, instruction, and recreation of their workpeople both in and out of working hours. It would be rash to claim an ability to speak the final word on the question, but under average American conditions, it is probably best for both employer and employee to rest content with the lower limit herein suggested — that is, thorough, honest, earnest attention to intra-plant conditions of hygiene and safety — accompanying a mode and scale of payment which enables the employee to realize the largest earnings possible to his capacity.

MATERIALS

CHAPTER IX

MATERIALS

IN a preceding chapter we assumed the manufacturer's point of view, from which every proposition in production is divisible into three terms: materials, labor and expense. In a more detailed examination of these three divisions of cost, we have reversed this order and have studied, first, expense, then labor, and lastly we come to materials. The reason for inverting the sequence by which the actual things would appear in practice, is that the justifying reasons for many of the wage-paying methods and broader industrial policies become clear only after we realize clearly the peculiar characteristics of the expense account and its shifting ratio to the other costs of production — its decreasing relative importance as the volume of production rises, and the consequent desirability of stimulating production through increased efficiency of labor, even at a considerable increase of labor cost. Labor was taken up next so that the tendencies of the various wage systems might be measured in the closest possible connection with the problem of costs. We come now to material, which, on account of its passive, inert character, seems best able to suffer the delay and seems also perhaps to offer less opportunities for profitable study.

Yet there is an aspect of material which we may advantageously consider for the moment, with the purpose of increasing our respect for it. If you trace almost any material thing back to its ultimate sources, you will find that a very large fraction of its entire value comes from the labor that has been expended upon it. In other words, almost all manufactured material, and even a good deal of what would be classed by manufacturers as raw material, is crystallized labor. The ore in the ground, the timber in the forest, the seed in the soil, even the land itself, is of small worth until the work of men's hands and brains has been expended upon it. But at each stage of the processes through which it passes, the labor of all the preceding stages is to be found literally materialized and embodied permanently in the partly finished product. What was "labor" to the preceding workman has become "material" to the following one.

Take the case of flax. The cost of the seed ready to sow is largely that of the labor it took to grow it. The crop of fibre fit for spinning adds to that the value of the work of cultivating, pulling, threshing, retting, hetcheling; in the spun thread a further increment of price appears, corresponding to the work of spinning; the woven linen is more valuable still by the measure of the labor of the weavers and the looms. Yet with all this "labor" accumulated in it, the linen is "raw material" to the shirt-maker. It is so again even more evidently perhaps with the ascending scale of values in the materials fashioned into an engine or machine; probably a small fraction of one per cent of the market price represents the ore in the ground from which they were made.

By "labor" of course we understand labor of administration and direction — labor of brain — as well as manual effort, and we do not purpose to ignore the successive additions of profit. Making these allowances, however, if we take the entire range of the history of almost any product or manufacture, we shall find that direct or indirect labor accounts for nearly all its value.

This, however, is a general argument, and, like a general rule, it may be of no particular service in a particular case. In any particular problem of production or industrial operation with which we are directly concerned, the relative importance of material as compared with labor or expense may be large or may be small. We are not particularly concerned with the history of the material before it came to us, except so far, perhaps, as that may influence its quality. We are a good deal concerned with its relative value in our own special formula:

Materials + Labor + Expense = Manufacturing Cost.

There are enormous differences in the relative weight these three variables assume in this formula as it is applied to various lines of manufacture. If our business is that of a heavy foundry or of steel structural work, materials may be by far the most important account to us, while labor takes a comparatively small part in our total costs. In an ordinary machine shop, the expense of fuel used in the power plant and the efficiency of the engine driving the shop may not cut a large figure in the total result; the important consideration here is to secure the highest efficiency from the workers and from the expensive mechanical plant (that is, from the machine and other labor) so as to turn out the maximum product; fuel expense is but a small fraction of the total expense burden which the product must bear. But in a central station selling power or light, the cost and quality of the fuel and the efficiency of the engines are of prime importance, for coal has now become the raw material, and the engines and boilers are the machinery turning out the product — that is, kilowatts at the switchboard — while labor is a relatively small item. Again, if you are furnishing insurance,[1] material practically disappears as an element of cost, and the account to which the highest and most skilled attention must be directed is that of risk.

The point deserves emphasis. It is not merely curious

[1] For purposes of emphasis, I have borrowed an illustration from James Newton Gunn. But in strict analogy, the "Material" used by an insurance company is *credit*, and is by no means inconsiderable.

or fantastic. It is not an idle play upon the interest of the theme to draw illustrations from an extreme case. The very first necessity in addressing ourselves to any problem of works management is to get a clear analysis of the situation, and this analysis must be not merely qualitative but quantitative. We must find the absolute and the relative weights of all the elements involved. Then, by comparison with standards, we can see clearly where the work of betterment will yield the largest results. We can attack the thing which is most important first, and work from the greater to the less.

Material (or as it is commonly called in shop language, "stores" when unfinished and "stock" when finished) is of course the central interest about which the whole organization of the plant is built up. Expensive machinery is installed to fashion it; workmen, skilled and unskilled, are hired to operate upon it; shop transportation systems are provided to handle it; it is the beginning and the end of the whole scheme of manufacture — the solid, physical nucleus upon which added value is built up by the various operations. It enters perhaps in crude and inexpensive form. It moves through the factory, gathering to itself, as it were, the values of men's time, of machine hours, of interest on investment in plant and equipment, of skilled superintendence and management. It emerges with all these incorporeal values of time and work and skill, materialized and incorporated in the finished stock. The increment may be one-tenth of the original cost or one hundred times that cost; it is evidently more, for example, in the case of the hair spring of a watch than it is in the case of a common grate bar; but there it is, crystallized in the completed work.

This value is rendered fluid again, so far as the plant creating it is concerned, by sale — that is, by exchange of the finished stock for money, with which more crude material, time, work and skill may be purchased.

Looked at in this way, material appears to be a matter of great importance, not only in itself, but in its relations to the sometimes larger elements of labor and expense. If stock is accumulated in excess of reasonable provision, it means at least idle capital, probable inconvenience and added expense in the ordinary movement of work, and possibly total loss through some change of plans, methods or patterns. If stores run short on even one item, it may mean stagnation to a whole group of manufactures thus left incomplete, and it may cause forced and expensive idleness to a whole department.

Stock, therefore, is really in a sense more important than the money it represents, for it has more potential energy for harm or for good. Yet it is notorious that many industrial plants (it might almost be said most industrial plants) are exceedingly lax in supervision and administration of the stock department or, as it is more often called, stores department. They are strenuously careful of the dollar in the safe, and flagrantly careless of the dollar in the stock bins. In short, it has often been remarked that stores-keeping is a very backward branch of works management. It has not in general received the same careful study, the same skillful work for betterment of efficiency, that has been put, for example, upon the question of labor. Stores-keeping methods are therefore likely to be found relatively inefficient, and for this reason might afford a very interesting field for study because there is more opportunity to secure economically important results.

In an outline so general as this we need not go far into the details of the subject, but we may summarize certain principles found advantageous in systematic handling of materials in manufacturing establishments.

Purchase is a specialized function in itself, and as we noted in a preceding chapter is committed to a purchasing agent, with such departmental assistance as the magnitude of the business may demand. The purchasing agent does not act on his own initiative, but on orders from the manufacturing department, often transmitted through the stores department. The duty of the purchasing agent is to see that materials of the proper description are ordered from sources that best meet the important conditions of quality, price, and time of delivery; he must then follow up the purchase order until the goods are received and quantity and quality verified. The material passes then to the storeskeeper, the invoices, properly certified, go to the auditor, and the purchasing agent's duties as to that particular transaction are finished. The most important equipment for the purchasing agent is thorough knowledge of the trades he has to deal with, supplemented by systematically filed catalogues, and authoritative information as to market quotations.

When it has been received at the works, material, as we have already seen, passes into the custody of the stores department. The chief functions of this department are four. First, it anticipates or meets the material wants of the factory, by securing the requisite supplies through the purchasing agent. Second, it receives and verifies the material when delivered, and provides for its orderly safekeeping. Third, it issues material as needed for the operations of the manufacturing department and receives it again in the finished state ready for shipment. Fourth, it maintains exact records of every receipt and issue and of balances remaining on hand.

In the performance of these duties an effective stores system should accomplish at least four things:

First. It should prevent over-investment and unbalanced accumulation. Of course, an extraordinary purchase to secure advantage of special market conditions, although leading to a temporary over-investment or overbalance of some item of stores, might yet be very wise.

This is an obvious exception which common-sense would suggest.

Second. It should give automatic warning of approach to a minimum on any item, so that the danger may be averted by filling up the low points.

Third. It should provide effective means for getting the material through the factory rapidly and without delays, even up to the final delivery of the finished stock.

Fourth. It should furnish records of every delivery, so that each order can be traced and identified with the job and with the workmen, and so that every part or piece may be accounted for and a continuous inventory of stock on hand may be obtainable.

It is apparent that these requirements connect the stores department very closely with the purchasing department on the one side, with the cost department throughout, and with the shipping department on the other side. Under able and energetic administration, indeed, it may be made (and in some modern institutions it is being made) not simply a bureau of custody and record, but a leader and a driver of the manufacturing superintendents and the operating officers. Even though it have no executive authority over manufactures, it can and it should disclose delays, inefficiencies, irregularities, and extravagances and bring them to the attention of the executives for correction.

So much for the functions of the stores department. As to its organization and conduct, also, we may define a very few prominent features which appear to advantage in some of the most advanced systems now in successful operation.

The first of these is the standardized listing of all standard stores, establishing standard nomenclature for every item. The use of symbols may be advisable, and in some cases dimensional figures and sketches in the standard lists may be expedient.

The second is the systematic and accessible arrangement of all stores — heavy stock, on the ground or on floors, lighter parts in bins or on shelving. Every section or item should be identified by a descriptive card or tag, properly displayed. It is not essential that all material should be in one central storehouse. It may be of great advantage to have heavy stores, especially, delivered and stored near to the point of use, and to have sub-stores where they will save the time of long journeys to and fro with requisitions and deliveries of stores to fill them. All the lighter and more valuable pieces, however, should be actually and physically contained in a store-room, and it is highly advantageous, when possible, to have a standard arrangement so that all sub-stores repeat the features of the main storehouse. All stores and stock should be under the charge of a storekeeper and every issue should be only upon regular requisition from proper and responsible authority.

Third. Careful and immediate record should be made of every withdrawal from stores and of every addition to every item, either in stock books or other permanent forms of record, or on the cards attached to the bins, or both, and the stock books may advantageously follow the classification system and arrangement of the stock bins.

Fourth. Carefully determined high and low limits should be fixed for every item kept in stock. Their size and range must depend, of course, on the rate at which each item is used and the length of time necessary to get a new supply. Provision should then be made to have a replacement order put in whenever any item falls to the minimum, so that a new supply may be bought or manufactured. Generally speaking, when an item has fallen to a minimum, a replacement order for the maximum quantity or a large percentage of it is put in, the minimum being fixed at such a point that it will last until the new lot is received, allowing a reasonable margin of safety for contingencies.

It is evident that special knowledge and talent, and skilled knowledge and discretion, are necessary in standardizing the elements of stores, in designing the arrangement of the stores rooms, and in determining maximum and minimum limits; but after that the routine becomes mechanical, and the ordinary functions of operating the system are merely clerical. In other words, we have here the same idea that has already been alluded to in connection with mechanical manufacture — the skill of the exceptional genius is permanently built into the machine or system, and the routine of the repetitive movements of that machine or system can be supervised by the cheaper intelligence and the lower-priced labor of the machine tender, or clerk, without fear of any deterioration in the quality of the product.

The actual movement of material — that is, shop transportation — is of course an expense account, and we met it when we were considering the distribution of expense; the discussion of the physical means for accomplishing such work belongs to the study of manufacturing-plant design and shop transportation rather than to this examination of the elements of management. The transportation of material, however, is so intimately associated with storeskeeping that it should be noted here that very important influences on economy may be exerted by the arrangement and the appliances adopted. In general, economy is favored by orderly progress of material in one direction through the works, the transportation lines of the various pieces or parts from the stores department, through the manufacturing operations, gradually drawing together in the order of assembly. This ideal, however, becomes more and more difficult to realize practically as our finished product becomes more and more complicated, and in many cases only an approximation to the ideal can be secured.[1]

[1] For an excellent treatment of this subject see "Industrial Plants; their Arrangement and Construction," by Charles Day; *The Engineering Magazine.*

Material and the transportation of material are furthermore very important in that they may dictate the location, and must control the design, layout, and equipment of the plant. To a very great extent, also, they will determine the selection of personnel, the form of organization, and probably the manufacturing policy.

Take, for instance, the case of a soap works. We shall have here the problem of a converging flow of materials to the kettle house, and from thence a stream of solid product to the shipping platforms. Up to the point of its solidification in the frames, our material is almost all fluid, is handled at very little expense by pumping, and allows great elasticity of arrangement.

Contrast with this the problem of the shipyard, which is fundamentally putting overboard an enormously heavy unit of product. Everything must be subservient to the location of the shipways; our material is almost all in heavy pieces, requiring heavy, fixed transportation systems, and the whole scheme is extremely rigid.

If, again, we have to deal with the manufacture of typewriters or cash registers, or some such light mechanical product turned out largely on automatic machinery, our problem is the accurate manufacture of enormous numbers of very small parts, their orderly convergence to sub-centers of assembling, and final assembling of the group parts into the finished machine. We should doubtless install such a manufacture in buildings of very good class, well lighted and well equipped, to attract a desirable grade of labor, with close communication between the various departments.

Lastly, if we are interested in powder-making, the condition which dominates the whole installation is that of possible explosion, and our ideal is a plant widely scattered into small units, none of them large enough to do disastrous harm, housed in buildings so light that they can blow to pieces without throwing heavy fragments, and isolated by natural or artificial barriers.

Here, then, as elsewhere in the manufacturing problem, we see that while our purposes are fixed, the means by which those purposes are reached must vary with each particular case or each particular class of cases, and the first and great essential to success is intelligent survey of our conditions, and then the application of scientific knowledge, intelligent methods, plain, practical common-sense to the provision of means for meeting them.

THE END

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