WORKS MANAGEMENT

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WORKS MANAGEMENT

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TO

THE MEMORY OF

MY FATHER

MANAGER OF THE ONE WORKS FOR A

QUARTER OF A CENTURY

"WRITE ME AS ONE THAT LOVES HIS FELLOW MEN"

PREFACE

In a former book (*Linseed Oil: An Industrial Manual*), the present writer has undertaken to discuss some of the conditions of efficiency in a special industry. It seems to be the current belief now that there exists an art of management without regard to special application; that there are underlying principles of efficiency germane to any business. Participation in this belief has suggested the present volume.

Every American is concerned that the United States may attain and maintain industrial supremacy. We no longer hold with Carlyle and Ruskin that machinery is bad. Machinery is a blessing to man. It has permitted him to substitute head work for hand work and has made him free.

We can have no industrial supremacy as we go on now. We are the most wasteful nation on earth. We burn up money in human lives, wasted by preventable disease. We recklessly consume our natural resources of land, forest and mine. Nowhere do we waste more thoroughly or more rapidly than in our factories; nowhere are we more childish than in some of our "business" methods.

The remedy is not this or that widely heralded "system." Industrial incapacity is not a specific disease needing an antidote: it is a characteristic of our frame, which we must survive and outgrow. No one of us is individually greatly to blame; we are all greatly to blame as a people, because we do not do the best we can. Profits are no index to efficiency. A man may be rich, yet a spendthrift.

The growth of a philosophy of works management has been an American growth. This philosophy is one that comes home to every individual, no matter how far he be removed (as he may think) from industrial affairs. Every man should know something of the new ideals of industrial management. Superficial knowledge may have little available value, but there are things so important that we must all know something about them, even if that something have only the force of a suggestion. To the administrator of the factory the subject of management comes with infinitely greater force. He has only in part originated it; it has had some portion of its genesis in extraneous sources; but he had best take hold of it and work with it if he, individually, is to survive.

This book is not (other than incidentally) a presentation of Taylorism. No one could more than the writer admire the thoroughness, the certainty, of the achievements of Mr. F. W. Taylor in cost-reduction, particularly in the machine shop and engineering works; nor the far-reaching scope of his conclusions; nor (most of all) that reticence and scientific spirit which induced him to say almost nothing about his work for nearly a generation, until he had proved it. But Mr. Taylor's machine shop accomplishments are largely matters of mechanical method rather than of management, and his plan of management is not a universal plan.

It has seemed that a presentation of some underlying principles of factory administration in general would be profitable. There are industrial management problems to be attacked by other methods than those which have had widespread recent discussion. There is no text-book on management; no primer for the novice. The subject cannot be taught in books. The novice must learn a great many things about management before he can intelligently read a book on the subject. Such books as we have are not the books that he should even then first read for his definite instruction. They deal with cost-keeping and records in a highly specialized way; with filing systems and conventions, and the mechanism of administration; with applications to some special trade which may have no interest to the reader, or with philosophical generalizations which may inspire us but give us no very clear conception of what it is all about.

The writer endeavors here to be specific as to some of the principles which underlie the methods of what seems to him good management. In truth, no one man could have had the experience to write such a book as it should be written; this book is admittedly sketchy, incomplete, in some phases very elementary; but one man may contribute what he best can. And every man should. For industrial administration is the vital human problem in its latest aspect. Increase of profit through better management costs no man anything and benefits every man in some measure. There can be no danger that the antagonism of labor organizations or the apprehension of the public may destroy the newly-created ideals of increased production. To increase the labor-hour production has been justly called the "highest human good." Dean Swift's well known eulogy of the man who makes two blades of grass grow where one grew before appeals to universal human nature.

The man who argues for a restriction of production, for "soldiering" deliberate, or for that apathy and conservatism which are equally harmful, is arguing against progress. He is on the wrong side of a moral issue.

Polytechnic Institute of Brooklyn,
New York, 1911.

Note.—A number of exercises, mostly numerical, have been incorporated at the end of the text matter (page 174). These are intended for use where the book is employed in class-room instruction, to emphasize the principles and illustrations presented. Many of these problems will seem absurdly simple to readers having had business experience; but it is thought that they are of a class in which the average student is exceedingly apt to err.

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WORKS MANAGEMENT

CHAPTER I

Management Units

The public has had every opportunity, in recent months, of learning the significance of the term *Scientific Management.* Not only have the engineering periodicals, with some degree of unanimity, propounded its principles; even the popular monthlies and the daily press have taken up this or that "system" as matters of news value and general interest.

Yet what scientific management really is may perhaps, in many minds, be still doubtful. Its exponents take too much for granted. They deal with generalizations and illustrations. For the most part they have failed to establish any fundamental scientific principle. Valuable as their discussions have been, they have been valuable as inspiration rather than as precepts.

As a matter of fact, management is rather an art than a science. To some extent, the manager, like the poet, is born, not made. To reduce management to a compact and complete body of rules and principles is chimerical, and any attempt to do so must fail. Yet there are, as in all arts, certain established methods, customs and expressions; defined things to be observed or avoided; a partly explored and charted route. It is an entirely feasible thing to present these matters in orderly form for the guidance of those whose avocations are supervisory and who seek to profit by the accumulated experience of others.

Management, then, is the science or art of reaching a given end with economy of means; of creating a material or ideal product with the minimum of expenditure. In the broadest sense, all of our interests call for the exercise of management. The education of a child is subject matter for the application of management of the highest type; but here the product is not of that material class with which we are at present concerned. From our standpoint, management is evidenced in the transformation of tangible objects from one condition to another by the application of human effort; and *good* management is applied when such transformation is efficiently consummated.

The conception of *efficiency* is with the engineer one of perfect definiteness. Efficiency is the quotient of the thing accomplished by the effort expended, of effect by cause, both being measured in the same definite unit. In heat engineering, this unit is the foot-pound, or British thermal unit. The obvious unit for measuring efficiency in management is the dollar; and from this standpoint, efficiency is the quotient of receipts by expenses, its numerical value being evidenced by profits.

The dollar (or its exchange equivalent) is scarcely a definite unit when we consider extreme variations in place and time. Possibly the final unit of efficiencies and values is the labor-hour; so that product should be measured in proportion to the hours of labor it commands, and cost in the labor-hours consumed. But this aspect of the question is academic rather than practical.

Cost Divisors

Of the two factors which define efficiency, the first, that of effect, receipts, products, is rather easily known. The determination of causes, costs, consumption, particularly if any degree of subdivision is desired, is more difficult. Since management efficiency is to be measured in dollars, the principal field for investigation is that of costs. A thorough study of costs therefore covers a large part of the whole field of management.

In order that statements of cost may have the greatest significance, all costs must relate to some common unit. Thus, in a power plant, we are to analyze not the whole cost of fuel in a month or year, but its cost *per kilowatt-hour* of output. In a gas works, the interesting figure is not the monthly consumption of coal, but the consumption *per thousand cubic feet of gas made.*

Here the cost "divisor" or "unit" or "basis," as it may be described, is a unit of production—the kilowatt-hour or the thousand cubic feet of gas. This constitutes a satisfactory sort of divisor only when the product is an invariable staple. In neither of the illustrations given is the product absolutely invariable. A kilowatt-hour in 2200 volt 3 phase alternating current is different, and may involve a different cost of production, from a kilowatt-hour in 220 volt direct current. A cubic foot of illuminating gas may vary in composition from day to day or from hour to hour; and a gas works produces and sells several things besides gas. Yet for commerical purposes the kilowatt-hour or the cubic foot of gas is frequently regarded as an invariable unit and is far more nearly so in point of fact than many others commonly treated as invariable.

Divisors of this sort—production units—are used in a large majority of industries; as in those concerned with the manufacture of fabrics, textiles, many oils, paints, liquors, food-stuffs and the like.

As an example of an industry in which the productive unit, although constantly employed for the purpose, is an unsatisfactory cost divisor, consider a paper mill. The definite unit is the pound (or hundred pounds) of paper. The expenditures for steam, labor, bleach, etc., are all reduced each month to the comparative figures per pound or hundredweight of paper made. Yet in a soda-process book-paper mill, a machine which could turn out 7 tons of heavy cartridge paper per day would be doing equally well when it produced 5 tons of ordinary book, or 3 tons of light "bond" paper. The whole expense for labor would be about the same in either of the cases; the unit cost of steam would be a maximum for the bond paper. If the pound of paper is used as the cost divisor, regardless of grade, then all divided costs will appear high in mills where much bond paper is made and all will appear low where cartridge is the product. A comparison of costs as between the two kinds of mill will be of little significance.

Furthermore, a similar condition of things holds in the average mill making several kinds of paper. The relative costs to produce the various kinds are guessed at, or prices are adjusted to meet competition, on the principle that the mill must be kept running; so that as a result certain grades may actually be sold at a loss.

There are two ways of improving this situation. If the product may be grouped into a few general classes, then costs may be kept over irregular periods during each of which a run is made on a particular class. Instead of obtaining average costs monthly, we should then obtain, say, after a three weeks' run on cartridge paper a cost statement for that run; after a further operation of six weeks on book paper a statement of the results of that operation; and so on.

The second method is perhaps simpler, and is the only one available when the orders are "short," *i.e.*, when the grades of product change frequently. It involves, besides usual monthly average statements, the obtaining of special costs by grades from records covering occasional runs on the different grades. This means, virtually, putting the factory under a "test."

The Consumption Unit Cost Divisor

There are certain industries in which no single staple product is made, but in which a single staple raw material is consumed. Take, for example, the case of a linseed-oil mill. Here flaxseed is crushed and the oil expressed, and two prime products—the oil and the pressed "cake"—besides a number of specialties, are sold. The oil is the most valuable product, and in determining its selling price it is necessary to consider the cost of the seed, the yield of oil and cake from the seed, the cost of mill operation and the price obtained for the cake.

The yield of oil varies greatly with the character of the seed purchased, but there is no corresponding variation in the cost of working. If oil production were used as a cost divisor, costs would appear high whenever a low-yielding seed was used. Yet this seed might be offered at so low a price that it would be desirable to employ it; or, conceivably, the cake value from such seed might be unusually high. From the management standpoint, the best cost divisor is the *consumption* unit, rather than the production unit; the number of bushels of flaxseed treated, for example. This is the usual cost divisor in linseed mills. In cottonseed-oil works, the divisor is the number of *tons* of seed worked.

Unit Costs

In the great majority of engineering works, the product is diversified, and no single divisor is possible. There may have been a time in a locomotive plant when a reduction of all costs to "so much" *per locomotive* would have been satisfactory; but at the present time weights and costs of locomotives differ to such an extreme degree that the only possible divisor is one of weight—the pound, the ton or the hundred tons; the last is the divisor used (when any is used) in the majority of the locomotive works of this country.

But suppose such works to build not only locomotives of a great variety of sizes, but also steam shovels, snow plows and (to make the illustration more striking) aeroplanes. Cost will then bear no relation to weight. The same condition holds in the large electrical manufacturing plants, where thousands of articles are made, ranging from a 15-cent incandescent lamp up to a hundred-thousand-dollar generator.

An obvious way of handling such cases would be to divide the works into departments, in each of which the volume of production of some standard product would be the cost divisor for the expense of operating that department. This is sometimes done. The same idea underlies a more common method of comparing costs in a works making a diversified product; that method in which instead of dividing total costs by a figure representing either product turned out or raw material consumed, no such thing as "total cost" is recognized.

In this system, every expenditure either for labor or for materials is immediately charged against the item of output affected. Thus, suppose a plant having a pay-roll of $1000 to produce concurrently 20 motors of a certain type. Under the cost divisor system, the labor cost would have been reckoned at $\$1000 \div 20 = \$50$ per motor. But suppose the plant to produce both 20 of these motors and 6000 incandescent lamps, under a pay roll of $1200; of which labor cost, $300 represented expenditure for producing lamps and $900 for producing motors. The cost of labor per motor is then $\$900 \div 20 = \$45$, and that per lamp is $\$300 \div 6000 = \$0.05$. Expenses for materials would be handled in the same way.

This, then, represents the extreme of complication in cost finding. As far as labor costs are concerned, the necessary data are derived from the time cards, on which the day-workman must show the disposition of every hour of his time; or the piece work slip, on which the contract worker must show the production for which he claims remuneration.

But with material costs more difficulty may be experienced. No special purchase of material is made in order that 20 motors (to return to our illustration) may be produced; the pig iron, sheets and copper are obtained in bulk, and may be intended for use not only in the building of these motors but also for various other purposes, perhaps some months in the future.

When these materials are purchased, it is impossible to charge them against the specific production in which they may be employed; and here is evolved the fundamental need for the *stock department* or *store room.* To this important department all standard materials will be charged. It in turn will charge against production those materials issued for production; and it must account, either by inventory or by charges against specific items of output, for everything it receives.

Unit Costs and the Consumption Unit Divisor

In the utilization of a cost-finding system to determine selling prices, it sometimes happens that various trade "differentials" or variations in price to cover more or less variation in product are found to be unfair. A linseed-oil mill, for example, sells not only raw linseed oil in bulk, and oil cake; it sells also various boiled and refined oils, meal (ground cake) and oil in barrels.

Unless some caution is exercised in computing unit costs in a case like this, an incorrect statement of cost of the staple product will be obtained. For example, most linseed-oil mills make a computation like the following:

Cost of 1 bu. of flaxseed....................	$1.00
Cost of mill operation, per bushel............	.25
	1.25
Produced 36 lb. cake, from which revenue derived was..............................	.36
Leaving as the cost of oil from 1 bu. of seed. .	.89
Nineteen lbs. of oil were produced: therefore cost per pound is.........................	.04684

Following usual practice, 375 lb. (50 gal.) of bulk oil (*i.e.*, oil in tanks) could be sold at the mill for $17.57. With the established differential of 2 cents per gallon for oil in barrels, this same oil, in a barrel, could be sold for $18.57.

Now suppose that during the period discussed 100,000 bu. of flaxseed were treated, the total mill operating cost of 100,000 × $0.25 = $25,000 consisting of $15,000 of expense incurred in producing raw bulk oil and unpacked cake, and $10,000 of such expenses as freight on oil and cake, cost of boiling, refining and barreling oil and grinding cake, etc. Suppose also that a part of this $10,000—say $1,000—was expended in barreling 35,000 gal. of oil; the remainder of the oil being delivered in bulk.

It would seem then that the mill operating cost for producing bulk raw oil is $15,000 or 15 cents per bushel, and that the cost per pound of such oil, at the mill, is not $0.04684, as computed, but ($1.00+$0.15−$0.36)÷19=$0.04158. The equivalent of a barrel of this oil could be sold for 375×$0.04158=$15.59; while the same oil, *in a barrel*, would cost

$$\$15.59+\left(\frac{\$1,000}{35,000}\times 50\right)=\$17.02.$$

This same point might easily be made the subject of several illustrations. The cost of barreling has now been separated from other expenses, and applied against the amount of oil barreled. A similar procedure should be followed with the costs of packing cake, grinding cake to meal and bagging the meal, and boiling and refining oil. In each case the expenditure will be separated from that incurred in producing the staple product, and applied against the specialties produced thereby.

The principle thus presented is applied in a broad way in many industries in connection with costs of freight on product. Freight expenses are not included in manufacturing costs; the latter cover only such expenses as are necessary to deliver the product ready for shipment; and the individual customer should be "quoted" such a price that he will ultimately pay the freight (if it is "prepaid") on his own particular shipment.

CHAPTER II

Cost Elements and Classifications

Standards of method and efficiency in industry vary widely. Every business has its conventions. No one has ever formally classified industrial enterprises. We have now an extension[1] of the Dewey decimal system, worked out in great detail to cover the range of engineering information; this might be used as a basis for our present purpose, but it would classify industries according to their technical rather than their commercial relations.

Physical proximity, similarity of organization or machinery or of raw materials used, are insufficient bases for grouping enterprises into a class. The broad division into "manufacturing" and "trading" industries is inadequate; so also is the grouping into engineering works (shipyard), process works (paper mill), and public works (city gas plant).

The present writer has suggested[2] the use of the "determining ratio" *first cost of plant ÷ value of annual output* as permitting of a degree of classification of industrial enterprises into groups characterized each by standards of equipment, organization and method; and as explaining certain dissimilarities in those standards between different groups. This determining ratio appears to be of useful application in connection even with individuals and machines as well as with industrial plants.

As a simple illustration, consider two power stations, precisely equal in capacity, one of which runs continuously while the other is merely the reserve auxiliary to a water power development, operating say not over 48 hours in the year. The first will have the most economical machinery attainable, almost regardless of cost; the latter will have the simplest and cheapest machinery, almost regardless of thermal efficiency. In the one case, operating expenses per unit of product are large in proportion to those fixed charges which are reduced by a large production divisor.

[1] Bulletin No. 9 of the University of Illinois Engineering Experiment Station, November, 1906.

[2] *The Classification of Industrial Enterprises*, Stevens Institute Indicator, January, 1908.

In the other case, the rate of fixed charge per unit of output is necessarily high, because the output is low.[1]

The two types of plant will usually be differentiated by any engineer by reference to what is called the *load factor*. The determining ratio here suggested is in a sense a load factor (or rather a function of its reciprocal), and is of more general appli cation than the latter. This question will not be discussed further. It has been introduced here because the reader, associated with some special industry, may find some of the principles presented to be inapplicable in his work and may therefore doubt their soundness. The prediction is ventured that when any well-ordered business departs widely from the practices to be discussed, the explanation will be suggested by a study of the "determining ratio" suggested, as it works out for that particular business.

The Elements of Cost

The items of cost which most directly and obviously enter into the total cost of any manufactured article are *labor* and *materials*. In fact, all expenditures are for one of these two items; perhaps ultimately for the first alone. But in the special sense, labor and material costs include only those expenditures for these commodities *which can be directly charged against the item of production considered.*

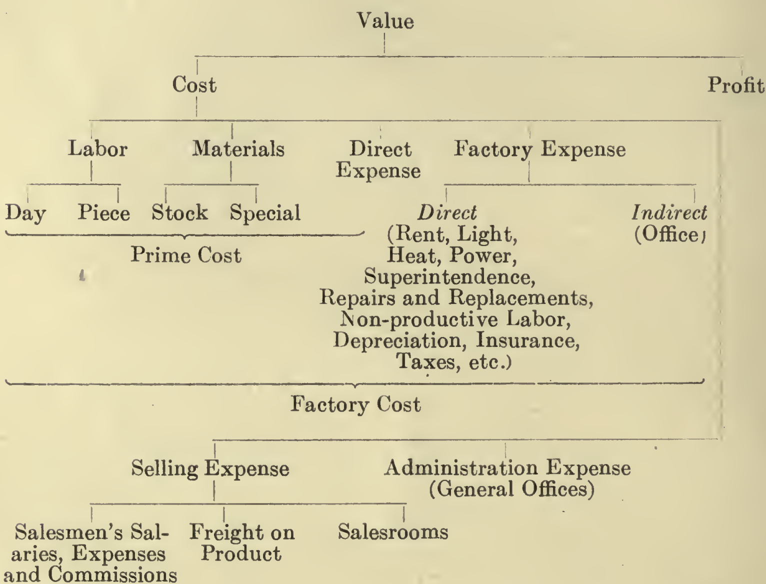
Besides these, there is a cost called *expense* or *burden*, which cannot be regarded as either labor or material. For example, in the building of an engine, provision might be made for certain tests and analyses of cast iron, involving an expenditure clearly applicable to this particular output. This would be *direct expense;* expense, because it is neither labor nor materials and does not become a part of the product; direct, because it is clearly chargeable to the engine in question. The three items, labor, materials and direct expense, make up what may be called the *direct cost.*

In addition, we have the item of *factory expense*, including such elements as lighting, repairs, taxes, and factory office

[1] So also the steadily-running power plant will have a high grade chief engineer, expert in fuel economy, while the reserve plant will get along with any man capable of starting up and keeping going in an emergency. In the first plant we will find flue gas recorders and composition indicators and all other devices likely to ensure economy through scientific method; in the second there will be nothing of the sort, since it is a matter of comparatively little importance whether the boilers are efficiently operated or not.

salaries; the total of which, added to the direct cost, gives the *factory cost.* Included in factory expense (in small works) is the general *administration cost.* In larger works, this expense may (because applicable to a number of factories or for other reason) be separately noted, as is also the item of *selling expense.*

The following chart then shows the grouping of the items which make up the market price of an industrial product:



The problem of cost keeping is to ascertain the amount of expenditure for each of these items, chargeable against each unit of product. This is a sufficiently easy matter where a single staple is either the product or the raw material; a far more difficult matter where the output is diversified; and in no case is this problem the whole problem of management.

The manager must not only know costs in this degree of detail; he must know the *reasons* for the costs which exist and whether they are what they should be. In order to determine as to the first point he must consider: 1. the price paid per unit of raw material (in the broadest sense, including all items), a matter of purchasing; 2. the consumption of raw material per unit of product, a matter of superintendence; 3. the cost of raw material per unit of output, a matter of general management.

In order to determine the degree of approximation of his costs to ideal costs, he must further investigate these three points in detail, attempting by scientific methods to establish ideal standards of performance for every operation. It is in this direction that the vocation of management is becoming dominated by the engineer. To determine ideal costs, and then to approximate them; this is the specific program of the industrial administrator. The first requires science; the second, executive ability. Thus far, training in engineering has, of all types of education, most nearly succeeded in combining the two.

Cost Keeping: Some Generalizations

Cost keeping is something more than a series of tabulations and comparisons based on books of account. It is true that bookkeeping furnishes much of the data for the statistician, and the latter should not call for original information, the essentials of which are already at hand in the hands of the accountants: but the cost keeper requires more detailed and comprehensive reports than any with which the accountant is concerned. The accountant seeks to know the facts; the cost keeper the reasons for the facts. The latter must constantly group, analyze and compare.

A cost system does not produce economies and it does add to cost of operation. It gives opportunity for a capable manager to produce savings, in comparison with which the clerical and other expense added to operating cost is relatively trifling. No cost system, however perfect, can take the place of competent management. Better no records of cost, with a strong executive, than the most perfect records, with a weak administrator. The manager whose grip is insecure will not strengthen that grip by adding to his office a costly clerical staff.

The question of cost of cost keeping is sometimes important, and often overlooked. Just how far the manager should go in the matter of statistical records is a debatable matter. In general, no record should be continued unless it is found useful to the management; but the determination of usefulness may be a matter of months or even of years. The system of keeping costs, as will have already suggested itself to the reader, must be specifically adapted to the business, or at least to that group of industries to which the business belongs. Yet the technicalities of these systems are such that it is desirable that the general plan of keeping costs should be devised by an expert in the matter, rather than by an expert in the particular business concerned. The carrying on of a system once devised may be conducted with ordinary clerical assistance; but the inherent tendency to degeneration found in industrial systems is such that in large enterprises it will probably always be best to permanently retain the cost expert.

Classification of Accounts

In the fabrication of staple or semi-staple products, the items of cost are so many that some grouping is necessary. A very broad grouping of expenditures has been given in the table on page 10. A more detailed grouping of the elements (particularly those entering into the *prime cost* or *factory cost*) is commonly attempted by accountants and cost keepers. The basis for such a grouping is what is known as the *classification of accounts.*

As an example, all operative expenditures, in a certain linseed-oil mill, were first separated from the selling and administration expense. These operating costs were then divided into "manufacturing expense," strictly so-called, and "sales deductions"—the expenditures for barreling, boiling and refining, etc., making up the $10,000 referred to on page 6. Manufacturing expense was itself subdivided as follows:

MANUFACTURING EXPENSE

Plant	*Steam*	*Labor*
Superintendent,	Fuel,	Pressmen,
Watchman,	Water,	Molders,
Lighting,	Engineers, firemen, etc.,	Strippers,
Mill expense,	Boiler repairs,	Packers,
Press cloths,	Oils and supplies.	Temperers,
Repairs.		Trimmers,
		Filterers.

This classification is peculiar in that both labor and material items are grouped together under "Plant" and "Steam."

A standard classification sheet of this sort is used in nearly every manufacturing business. Special forms have been developed for gas works, paper mills, locomotive shops, etc. The list of accounts, with short instructions regarding them, privately issued by one large corporation to its accounting staff, makes a pamphlet of over a hundred pages. Railways group their operating expenses into five general classes:

Railway Operating Expense

1. Maintenance of way and structures
2. Maintenance of equipment
3. General expense
4. Traffic expense (commercial)
5. Transportation expense { Power / Operation }

The Interstate Commerce Commission prescribes in detail the names of the subordinate accounts included in each of these five groups, for both railways and street railways. For a small road of the latter class, 39 operating accounts are used; for a large road the number of accounts runs up into the hundreds.

The following (from the 1909 Report of the New York Public Service Commission, Second District) shows the average operating costs of 75 electric railways in New York state, in cents per car mile. The numbers first given refer to the standard enumeration of accounts.

Maintenance of Way and Structure:		
1. Track and roadway	1.602	
2. Electric line	.353	
3. Buildings	.091	2.046
Maintenance of Equipment:		
4. Steam plant	.060	
5. Electric plant	.068	
6. Cars	.768	
7. Electric equipment of cars	.600	
8. Miscellaneous equipment	.039	
9. Shop expense	.125	1.660
Operating Power Plant:		
10. Wages	.345	
11. Fuel	.476	
12. Lubricants	.023	
13. Miscellaneous supplies and equip.	.039	
14. Hired power	2.163	3.046
Operation of Cars:		
15. Superintendence	.335	
16. Wages, conductor	2.507	
17. Wages, motormen	2.570	
18. Wages, miscellaneous car service	.250	

19. Wages, car housemen............	.448	
20. Supplies car service..............	.124	
21. Miscellaneous expense car service.	.324	
22. Hired equipment................	.045	
23. Cleaning and sanding track.......	.125	
24. Removing snow and ice..........	.109	
25. Undistributed expense...........	.063	6.901
General expense:		
26. Salaries, general office...........	.333	
27. Salaries, clerk...................	.281	
28. Printing and stationery..........	.046	
29. Miscellaneous office expense......	.064	
30. Store expense..................	.046	
31. Stable expense..................	.033	
32. Advertising and attraction........	.138	
33. Miscellaneous general expense.....	.344	
34. Damages........................	.985	
35. Legal expense due to damages....	.048	
36. Legal expense, miscellaneous.....	.072	
37. Rent, land and buildings	.050	
38. Rent, track and terminals	.197	
39. Insurance.....................	.208	2.845
Total......................		16.498

In general, the greatest number of specific accounts is included in that class which was formerly lumped by bookkeepers as "manufacturing" (factory) cost. It will easily be appreciated that to devise a broad and flexible classification of accounts for any business involves much detailed knowledge of that business. A proper classification is fundamental to proper accounting, to cost-keeping, and in a large measure, to good management. Many firms keep their classification systems as much to themselves as possible; they represent too great an expenditure of time and thought to be given freely to the general (and competing) public.

Method of Using the Classification

Whenever an expenditure is made, or when goods are delivered from the store-room, a corresponding charge is made to the proper account. If the classification of accounts has been properly made, there can never be any real question as to what account is chargeable.

A method sometimes employed is to use a voucher (see page 15), which is practically a restatement of the amount of the bill, on the reverse of which the whole classification of accounts is printed, the amount of the bill being entered opposite its appropriate classification. This method has the objection that whoever receives the voucher for signature sees and may copy the entire classification system.

The preferred plan is to designate all accounts by numbers or letters, the meaning of which need be known to only a few of the clerical staff. The appropriate number is merely noted on the face of the voucher.

VOUCHER

(Face)

New York, *Jan'y* 2, 1902

AMERICAN PRODUCT COMPANY,

To *John Smith,* Dr.

1901 *Dec.*	12	200 *empty secondhand refined oil barrels* @ $1.20	$240			

Vouchered by *A. B.*	Examined by *C. D.*	Received *January* 3, 1902 of AMERICAN PRODUCT COMPANY
Approved for Entry *C. D.*		*Two hundred and Forty* Dollars $240.00 in full payment of above account.
Approved for Payment ....*E. F*........Auditor ....Secretary ....Treasurer		This voucher must be signed by the firm or individual in whose favor it is made. When signed by another, the authority for doing so must in all cases accompany it. Name and title of person signing must be given in full. *John Smith.* ....

VOUCHER
(Reverse)

Voucher No. 695					*Brought forward,*				
AMERICAN PRODUCT COMPANY					**Labor**				
Date Recorded, *Jan'y* 2, 1902					Pressmen,				
Date Paid, *Jan'y* 2, 1902					Molders,				
favor					Strippers,				
John Smith					Packers,				
for account					Temperers,				
Philadelphia mill					Trimmers,				
MANUFACTURING EXPENSE					Filterers,				
					Oil sales account,				
Plant Superintendent,					Cake and meal sales,				
Watchman,					Executive expense,				
Lighting,					Selling expense,				
Mill expense,					Barrel account,	240			
Press cloths,					Boiling and refining,				
Repairs,					Freight and drayage,				
					Insurance,				
Steam Fuel,					Taxes,				
Water,					Equipment,				
Engineers, etc.,					Material,				
Boiler repairs,					Discount,				
Oils and supplies,					Contingent fund,				
Forward,					*Total,*			240	

It is not common practice to make out separate vouchers for payments of wages, although if payment is made by check it would be logical to do so. A usual method is to take the receipt of the paymaster or manager for the whole amount of the pay roll, the attached pay-roll or the receipt itself showing the standard accounts chargeable.

CHAPTER III

Statistical Records

The diagnosis of management is continual, but formal records need be made only at more or less intermittent periods. The period-interval for the recording of essential data may be practically zero, as when a recording instrument is employed; and from this minimum it may range up to hourly, daily, monthly, and even yearly. Much depends upon the kind of datum to be noted. In general, detailed data are recorded more frequently than summarizing data; consumption records may be kept daily; price records, for every purchase; while "cost statements" are more frequently taken at monthly intervals.

Establishing Consumption Records

The class of records in which no dollar unit appears—like that of coal consumption per kilowatt-hour in a power plant—is of the first importance from a management standpoint, and it is in the devising of such records that the maximum of executive capacity is frequently required. Many offices spend time and money on perfectly useless consumption records. Others leave gaps that destroy the usefulness of a whole system. The ideal is to make the records so consecutively logical that there is a direct linkage of cause and effect, and to discard any element that is not an essential part of this linkage.

For example, in a power plant, consider the question of coal consumption per kilowatt-hour. The following are among the factors concerned: Heat value of the coal; boiler efficiency; load on the equipment, boilers and engines.

The heat value of the coal may be fairly constant, but in progressive plants it is common practice to check this by analysis. The boiler efficiency is highly variable; to determine this accurately, we should need to know (besides the heat value of the coal) the weight of coal burned, weight of water evaporated, feed water temperature, steam pressure, and quality or dryness of the steam. Since much coal is consumed in banking fires, or when the load is light, it is desirable also that there be a continual record of the number of boilers (or amount of heating surface) in service. In addition, to throw light on the reasons for variation in boiler efficiency, there should be some attempt made to ascertain the amounts of various of the larger losses; which would involve recording the flue gas temperature and composition, with possibly the weight of ash and the percentage of coal in the ash.

The engine efficiency (for engines of a given type) will vary chiefly with the load on the engines; so that this record must also be obtained, either by the use of the indicator or by reading from instruments the electrical output, if the engines drive generators.

This brief, rough outline will suggest the following prime records:

1. Heat value of the coal, per pound; every car-load or shipment.
2. Weight of coal burned; intervals from 1 to 24 hours.
3. Weight of water evaporated; intervals from 1 to 24 hours.
4. Feed water temperature; by recording instrument.
5. Pressure of steam; by recording instrument.
6. Dryness of steam (not necessary, unless the load fluctuates greatly).
7. Amount of heating surface in service, each hour.
8. Flue gas temperature; by recording instrument.
9. Flue gas composition (per cent. of carbon dioxide); by recording instrument.
10. Weight of ash; intervals from 1 to 24 hours.
11. Percentage of coal in ash; intervals from 1 to 24 hours.
12. Load on engines; preferably a continuous record.

Some of these records will check others; the flue gas temperature and composition, for example, will usually be in harmony with the boiler efficiency, and the load on the engines will bear a more or less definite relation to the amount of water evaporated.

If we drop the record marked 6 as an unnecessary refinement, the eleven data remaining might lead to the following principal and auxiliary statistical records:

Principal

a. Thermal efficiency from coal to steam.
b. Thermal efficiency from steam to power.
c. Thermal efficiency from coal to power.
d. Pounds of coal consumed per unit of power output.

Auxiliary

a1. Heat imparted to each pound of steam, from feed water temperature to boiler pressure.

a2. Average equivalent rate of evaporation (pounds of water evaporated, from and at 212° F., per square foot of heating surface, per hour).

a3. Percentage of heat of fuel lost to the stack, as shown by flue gas temperature and analysis.

a4. Percentage of fuel lost to ash pit, as shown by weight and analysis of the ash.

b1. Average load factor on engines (average load divided by rated capacity).

It is not claimed that the prime records, or the auxiliary and principal statistical records, here presented, are complete; in the first named, particularly, there is room for extension. Such matters as draft conditions might be noted; if there are, as usual, several types of engine in the plant, various additional items of information may be needed. Particulars as to vacuum, etc., would usually be desirable as throwing light on variations in engine efficiency.

But we are now studying not power-plant operation, but statistical records; and this simple analysis will answer for its purpose. The four principal records called for show the variation in the vital figure we are after—the coal consumption per unit of output—and the leading factors which affect that figure.

Unnecessary Statistics

Many good managers would also tabulate a large number of additional observed or deduced facts, such as:

m. Water evaporated per pound of coal.

n. Water evaporated per pound of coal from and at 212° F.

o. Steam consumption per kilowatt-hour.

p. Rate of combustion (pounds of coal burned per square foot of boiler grate per hour).

q. Characteristics of coal, as to moisture, ash, volatile matter, and fixed carbon.

Of these items, (m) is an indefinite measure of efficiency and n is only another expression for the "principal statistical record" (a). Similarly, (o) is an alternative (and less definite) way of stating the result called for under (b). In some cases the record (p) may be desirable, either in place of, or supplementary to (a2); while the items under (q) are usually kept sufficiently under observation by occasional action. Such records as those suggested by (m), (n), and (o) are clearly superfluous and when used instead of (a) and (b) are usually employed merely because of a lack of sufficient technical knowledge to make the computations necessary for determining (a) and (b).

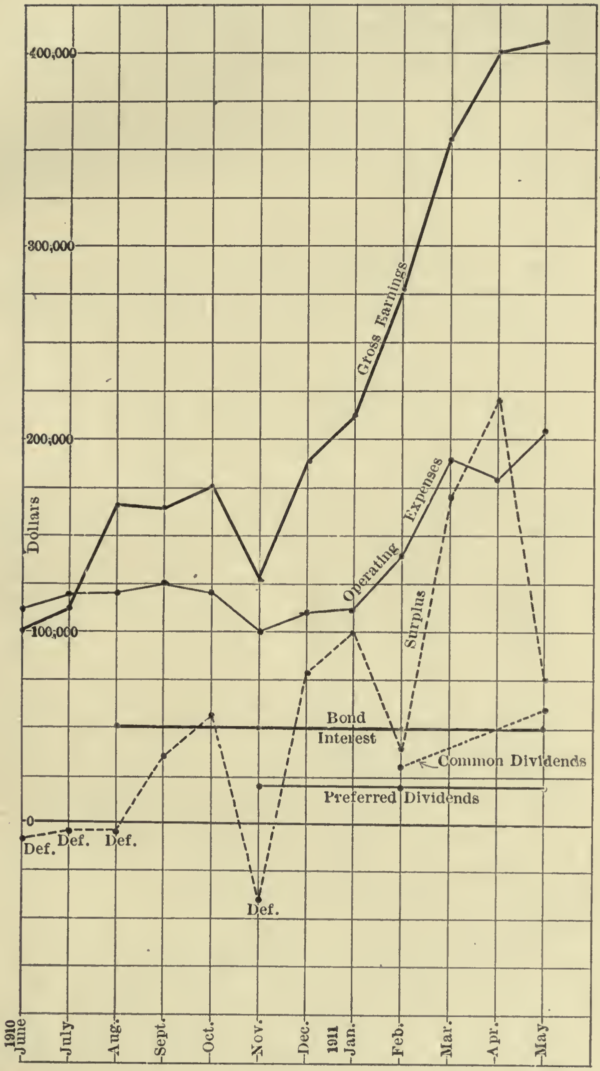
Graphical Statistics

Consider a statement like the following:

STATISTICAL RECORD OF THE A. B. C. CO., FOR THE FISCAL YEAR 1910–'11

Month	Gross earnings	Operating expenses	Interest on bonds	Preferred stock dividend	Common stock dividend	Surplus
1910						
June......	$100,000	$112,000	....	....	....	$12,000 (deficit)
July.......	110,000	115,000	....	....	....	5,000 (deficit)
August....	165,000	120,000	$50,000	....	....	5,000 (deficit)
September.	160,000	125,000	....	....	....	35,000
October....	175,000	120,000	....	....	....	55,000
November.	130,000	100,000	50,000	20,000	....	40,000 (deficit)
December..	189,000	110,000	....	....	....	79,000
1911						
January...	212,000	112,000	....	....	....	100,000
February...	280,000	140,000	50,000	20,000	30,000	40,000
March.....	360,000	190,000	....	....	....	170,000
April......	400,000	180,000	....	....	....	220,000
May.......	410,000	205,000	50,000	20,000	60,000	75,000
	2,691,000	1,629,000	200,000	60,000	90,000	712,000

The totals at the foot of this table are significant, but (to the writer—perhaps not to a trained accountant) the details, without concentrated mental effort, are meaningless. Now take the accompanying chart, which represents the same figures graphically. We are looking, not at a printed description, but at a picture; and the innate sense of direction, rather than any conscious intellectual effort, tells us what happended to the A. B. C. Co. during its fiscal year. Figures and chart both tell the same story; but the chart tells it more quickly and clearly.



Graphical Statistical Record of the A. B. C. Co. For the Fiscal Year 1910–'11.

Even the chart, however, does not give an ideal record. The strong upward trend in gross earnings is evident, but it suggests, without defining, what the year's gross earnings will be. The surplus curve is highly irregular, and is necessarily made so by the quarterly disbursements for interest and dividends.

Totalized Curves

Let us draw off from the previous record the following new tabulation:

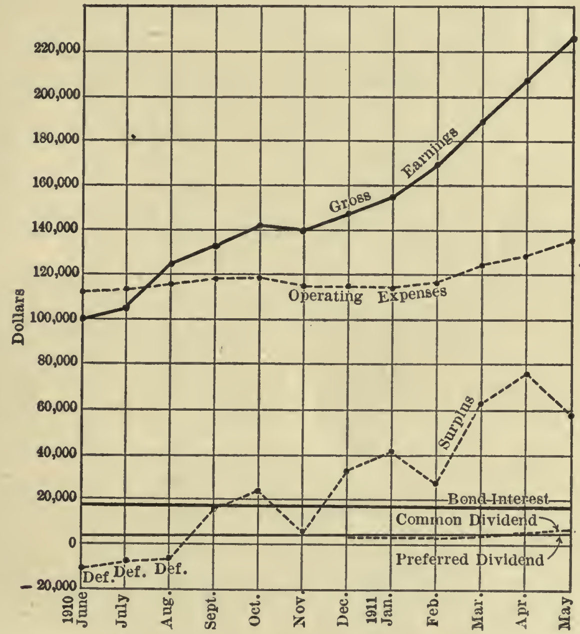
STATISTICAL RECORD NO. 2

Averages per Month, from the Beginning of the Fiscal Year to and Including Month Specified

Month	Gross earnings	Operating expenses	Interest on bonds	Preferred stock dividend	Common stock dividend	Surplus
1910						
June......	$100,000	$112,000	....	....	....	$12,000 (deficit)
July.......	105,000	113,500	....	....	....	8,500 (deficit)
August....	125,000	115,667	16,667	....	....	7,334 (deficit)
September.	133,750	118,000	....	....	....	15,750
October ...	142,000	118,400	....	....	....	23,600
November.	140,000	115,333	16,667	3333	....	4,667
December..	147,000	114,571	....	....	....	32,429
1911						
January...	155,125	114,250	....	....	....	40,875
February...	169,000	117,111	16,667	4444	3333	27,445
March.....	188,100	124,400	....	....	....	63,700
April......	207,374	129,455	....	....	....	76,919
May.......	224,250	135,750	16,667	5000	7500	59,333

Chart 2 shows these results. The irregularities in the "surplus" curve are now much less conspicuous; they appear in proper relation to the year's business. It would have been equally satisfactory to have charted totals instead of averages, in this particular instance, but the latter basis has been adopted as more nearly representing the method when applied to the graphical tabulation of *consumption* records. These new curves show at any moment the condition of things *for the expired portion of the fiscal year*, at the given date.

It may be noted that, under this present method, fluctuations will be necessarily more perceptible at the beginning of the year, and that they will have less and less influence on previous results as the months go on. To remedy this, it might be desirable in some cases (particularly with consumption records) to totalize all figures for the previous twelve months, regardless of the date of beginning of the fiscal year. But with the average manager, "last year" means ancient history. The living present is what concerns him; his interest lies primarily in what is being accomplished *this* year. Furthermore, it is useful in many industries to compare results in a given month with those of *the same month* in previous years; for manufacturing plants have their seasonal conditions.



Graphical Statistical Record (No. 2) of the A. B. C. Co. For the Fiscal Year 1910–'11.
(Amounts Totalized and Averaged.)

Totalizations and Comparisons

The following classes of final records and charts may then be kept:

1. The *chronological*, as in the first chart, page 21.
2. The *totalized*, from the beginning of the fiscal year, as in Chart 2.
3. The *comparative chronological*, in which figures for successive months of *various years* are tabulated on one sheet or diagram, the same scales of months and figures being used for all the years.

4. The *comparative totalized*, like 3, excepting that the entry for each month is a total or average figure.

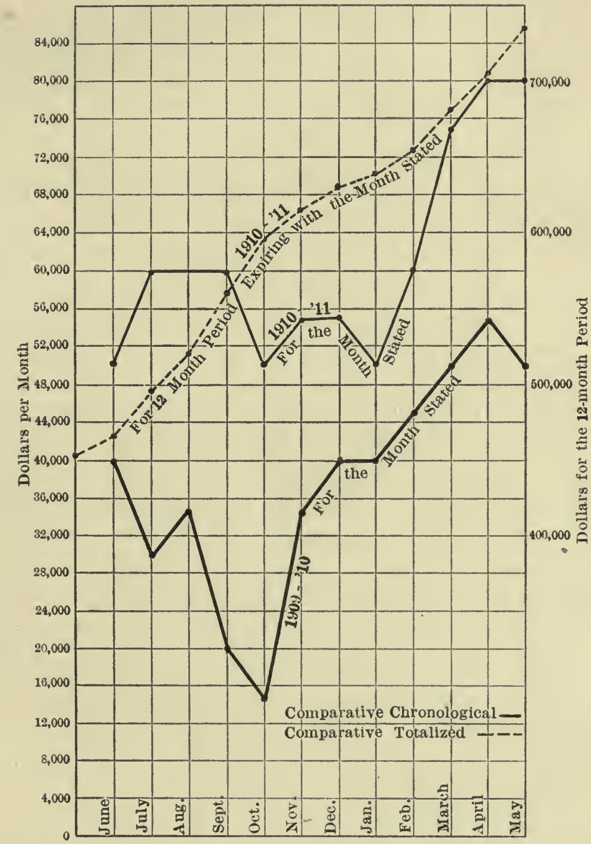
As permitting of illustrative examples, take the set of figures given in the following table:

STATISTICAL RECORD OF THE A. B. C. CO. (No. 3)

OPERATING EXPENSES

Months	Mill A	Mill B	Total
1909			
June	$40,000	$ 10,000	$50,000
July	30,000	12,000	42,000
August	35,000	16,000	51,000
September	20,000	28,000	48,000
October	15,000	25,000	40,000
November	35,000	15,000	50,000
December	40,000	35,000	75,000
1910			
January	40,000	45,000	85,000
February	45,000	55,000	100,000
March	50,000	60,000	110,000
April	55,000	70,000	125,000
May	50,000	55,000	105,000
June	50,000	62,000	112,000
July	60,000	55,000	115,000
August	60,000	60,000	120,000
September	60,000	65,000	125,000
October	50,000	70,000	120,000
November	55,000	45,000	100,000
December	55,000	55,000	110,000
1911			
January	50,000	62,000	112,000
February	60,000	80,000	140,000
March	75,000	115,000	190,000
April	80,000	100,000	180,000
May	80,000	125,000	205,000

From the figures in the first column, we derive solid lines which form the "comparative chronological" graphical record (No. 3). A "comparative totalized" curve would be based on the following record (No. 4) and is also shown (*dotted*) on page 25.



Graphical Statistical Records (Nos. 3 & 4) of the A. B. C. Co. Operating Expenses, Mill A

STATISTICAL RECORD OF THE A. B. C. CO. (NO. 4)

Operating Expenses

Twelve Months Ending	Cost to Date, Mill A
1910	
May	$455,000
June	465,000
July	495,000
August	520,000
September	560,000
October	595,000
November	615,000
December	630,000
1911	
January	640,000
Februrary	655,000
March	680,000
April	705,000
May	735,000

In addition to these, in a business having several independently operated plants, there is an unending opportunity for side-by-side comparisons of the efficiency of the different mills. The obvious record in this case is that which shows on one diagram the chronological (type 1) performance of all of the mills with respect to some one particular feature. It is the record numbered (3) adapted for several mills at concurrent time instead of one mill at various times.

Consumption Totalization

Let us assume this data:

Months	Coal consumed, pounds	Output, kilowatt-hours	Pounds coal per kilowatt-hour
January	800,000	200,000	4.0
February	1,200,000	240,000	5.0
March	1,400,000	350,000	4.0
April	1,100,000	275,000	4.0

If to these figures we apply the method suggested under (2) in the previous paragraph, we obtain:

Months	Coal consumed to date, pounds	Output to date, kilowatt-hours	Coal per kilowatt-hour, to date
January........	800,000	200,000	4.0
February.......	2,000,000	440,000	4.55
March.........	3,400,000	790,000	4.3
April..........	4,500,000	1,065,000	4.23

The figures in the last column are those significant to the manager, and such figures are typical of the mass of detail found in well-kept consumption records. If in the month of May, the load, in this illustration, fell off to 10,000 kw.-hrs., the coal consumption might easily be 200,000 lb., giving coal per kw.-hr., 20 lb.—a sky-high figure. To know what this really means in the year's business we have only to carry on our totalization: the coal consumed to date becomes 4,700,000 lb., the output 1,075,000 kw.-hrs., and the consumption rate 4,700,000 ÷ 1,075,000 = 4.38. The bad month has put up the average from 4.23 to 4.38. This is what we want to know as well as the startling fact that the consumption rate for that month was 20.0. On the other hand, a good month, with high production, improves efficiency rates more than its own unit consumption figures alone would indicate.

Special Records

A striking modification of the second of the charts presented in this chapter (page 23) would be possible by laying off downward from the "gross-earnings" line successive distances representing operating expenses, interest, dividends and surplus. The point at which funds became available for dividend would thus be clearly shown.

A graph sometimes prepared is one showing the relation between improvement expenditures and increase in gross earnings. If the latter are laid off horizontally, and we assume (not an uncommon assumption) that an improvement should "pay for itself" in six years, then the tangent of the angle made by the graph with the horizontal should be 6.0.

Cost keeping statistics, for completeness, should include a great variety of factors. The statistical interval should be short and the tabulations prompt. There is no use in crying over spilled milk, but quick action may help. Subdivision of data should be carried to the farthest possible extent. Such matters as rates of wages, length of working day, conditions controlling the cost of supplies, climate, weather, rainfall, etc.—all of these may have to be considered as secondary or subordinate data in the general analysis: and the raw material for such data should be kept at hand.

CHAPTER IV

Labor

Practically speaking, all costs in industrial production are ultimately labor costs. The vital problem in management is the reduction of labor cost, or, to put it in a phrase probably more acceptable to many people, it is the increase of human productiveness, which may either reduce the average length of the working day (to 5 or 6 hours, as some think) or, by decreasing commodity values generally, elevate the standard of living. Not only from this standpoint, however, is a high labor-hour production desirable: the fixed costs of maintaining a manufacturing plant—such as rent, taxes, and the like—are so great that in order to keep them low per unit of output, the output must be high. Efficiency in workmanship is in a large proportion of works less important in itself than in its effect on the rate of fixed cost. In order to secure this last beneficial effect it is sometimes (if not usually) even permissible to *increase* the labor cost rate.

Without supervision and the spur that supervision gives, men degenerate in productiveness. There is an innate tendency toward inefficiency that must be checked by special means. Such a tendency, during the early part of the present generation, had shown pronounced results in the great majority of engineering workshops. The powerful stimulus which is now being applied to offset it had its origin in the apparently unrelated factor, the introduction of improved tool steels.

The "self-hardening" or "high speed" steels have had two curious effects. In the first place, they have compelled the redesign of practically all of our machine tools. The old machines were too light to stand the heavy cuts and feeds which the new tool steels invited. Secondly, the new steels have afforded the opportunity for an increase of two to four times in the speed of cutting metals.

This increased machine tool production has in a subtle way been associated with a general increase (where proper methods have been applied) in labor efficiency. Men have not only turned out three times the former amount of work in a lathe or planer; they have learned how to triple their production in operations where no improved steels were available, in such work as shoveling, moving materials, etc.

Labor Cost Apportionment

Some trouble and expense are necessary in order to learn the correct distribution of labor costs in a plant making a diversified output. Apparently, no invoices are received for labor, yet in reality the pay roll is an invoice which, like any other, must be classified in two ways. Its payment must be recorded as squaring accounts with its maker—the workman, and also as against some specific item of production.

A magazine article[1] describes the system employed at the Lynn works of the General Electric Company, where some 5000 articles are made. Here about one-third of the employees are on day work, two-thirds on piece work. For the various operations involved in constructing and assembling the 5000 items of production, there exist some 20,000 piece work standard schedule rates.

The result of the system to be described is such that within a day or two after the pay-roll period the manager knows the exact distribution of the $150,000 weekly labor expense.

No man employed works an hour of time excepting under the authority of a numbered *shop order*. Some of these, as for "expense" labor, are standing orders; the great majority are issued as occasion requires. Every shop order number includes six digits. The first of these refers to the general classification: 1. production, 2. construction (about the works), 3. repairs (made for customers), 4. expense, 5. experimentation, 6. engineering and designing. The second and third digits describe one of the 50-odd classification subdivisions, while the last three specifically describe type, size, finish, etc.

Thus, order 127436 might refer to

1. Production.

27. Enclosed arc lamp.

4. 220 volt. d. c. type.

3. 2.8 amperes.

6. Black japanned finish.

[1] *The Engineering Magazine*, March, 1908.

The shop orders containing this number are each a direction to some one workman to do some one thing necessary for the production of such enclosed arc lamps. They contain, besides the shop order number, the workman's number, the date, a brief statement of what is to be done, with blue prints and specifications attached if necessary, and a signature.

The "invoices" for labor are of two kinds: the *time card* and the *piece work slip*. Each originates with the employee to be paid. The day worker writes on his time card the number of hours spent on each shop order, signing his name or number. The piece worker, in the same way, signs a statement of the number of pieces made and the appropriate piece work schedule number, for each shop order on which he has worked.

These two forms are of course arranged for necessary checking and clerical entries. They then go to the paymaster's department, where they are grouped *by workmen's numbers*, and the amount due each man is computed. Next they pass to the cost department, where they are arranged in order of *shop order numbers*, each of which will require, on the average, 200 cards, about 1000 separate shop orders being current in an average week. The cost department then draws up a statement showing for each shop order number the expenditure for both day work and piece work. Summaries are made for various groups of output, and the final summary appears on a slip the size of a visiting card, in the following form:

Week Ending May 31, 1907

Production	65.09 per cent.
Construction	11.81 per cent.
Repairs	6.50 per cent.
Expense	8.40 per cent.
Experimentation	4.10 per cent.
Engineering	4.10 per cent.
	100.00 per cent.

The slightest variation of these percentages from normal may be investigated by referring to the itemized figures in the cost department.

This system shows the cost of labor for producing, say a shop lot of 100 lamps, but not necessarily the cost of labor for the 27 lamps which may have been purchased by John Smith of Buffalo. That is, costs are not determined for individual customer's orders, nor is it necessary that they should be, when the lamps sold to Smith are precisely the same as hundreds of lamps sold elsewhere.

But where a less standardized product—say large steam engines—is being made, costs will vary even on two precisely duplicate items of product; and in such cases the record is sometimes kept for individual customer's orders. No additional complication is involved, excepting possibly two or three more digits on the shop order number.

Systems of Paying Labor

The most common method of purchasing labor is by the unit of time; in the lower grades, by the hour. The higher in the scale of life the laborer stands, the longer, generally speaking, is his wage interval: the ditcher is paid by the hour, the bookkeeper by the week, the engineer perhaps by the month, the manager possibly (nominally) by the year; and with this increasing wage period there goes an increasing lack of relation between the number of hours worked and the rate of compensation, the assumption being, apparently, that the higher grade workman may be depended upon to consider rather the doing of his work well than the time he spends on it.

When we pay a man by the hour, we virtually assume that it is his time that is of value to us, although this is in very few instances the actual case. The day wage system is contrary to human nature. It encourages the man to husband his strength either for his amusements or that he may not exhaust his market; and it encourages the master to drive the man regardless of humanitarian, sociological or even higher economic considerations.

Piece work is diametrically opposed to this. Here we pay the man for what he produces, regardless of the time he spends in producing it. Under piece work, the relation of master and man ceases, and there is substituted the relation of two parties to a business transaction. The interest of the workman should now be, the highest rate of production possible.

The interest of the employer is more difficult to define: and here lies the whole explanation of the failure of piece work in practice. Piece work was originally introduced solely as a method for reducing labor costs. In order that piece work might be attractive to the man, it had to increase his earnings. In order that it might interest the employer, it had to reduce the labor cost to him per piece produced. When it did both of these things it demonstrated conclusively *past bad management.*

For example, a man made 20 bolts in a day, receiving the day-work wage of $2.00, equivalent to a cost per bolt of 10 cents. Put on piece work, at a rate of 8 cents, he produced 30 bolts per day, making his wage $2.40. The man was satisfied, and the employer should have been. But after a time the man unwisely allowed his production to increase to 50 bolts per day, bringing in for him $4.00.

Then the employer felt this to be too high a wage for a man of this class; he reasoned that if the man could produce 50 bolts a day he must have been "soldiering" frightfully in the past when his regular day's output was only 20 bolts. Acting on resentment and greed, he cut the piece work rate to 6 cents.

The workman now finds himself obliged to turn out 33 bolts daily—70 per cent. more than his former day's work output—in order to make his former day-wage. At maximum effort, he can make only $3.00 a day. He concludes that piece work is bad; that it has increased his burden 70 per cent., an evil not to be offset by the possibility of somewhat higher earnings than the old, on condition of the most strenuous exertion; a possibility which, moreover, he feels may at any time disappear.

If we analyze this unfortunate state of affairs, we find:

(a) The original piece work price of 8 cents was a mere guess; if the man was capable of making 50 bolts a day, and the manager had known it, the latter would probably never have agreed to such a price as he did agree to.

(b) The employer was shortsighted in losing sight of the fact that a production of 50 bolts per day, even at 8 cents, was profitable to him from the standpoint of *fixed charge reduction* as well as from the labor cost standpoint.

(c) The workmen must have been cheating the employer in the past.

(d) The employer must have been a poor manager not to have found this out.

These considerations will serve to introduce what may be described in general as "profit-sharing" systems of wage payment: systems which differ from strict piece work psychologically rather than in essence.

Profit-sharing[1]

A major premise of the profit-sharing advocates is that the average man, under old style management, does about one-third as much as he might do: a premise which the present writer is on the whole prepared to endorse. The difference in productiveness of the average man and the first-class man, working under proper conditions, is simply tremendous. In order to triple present production, modern management proposes:

(a) To furnish the workman with an ample supply of tools scientifically correct.

(b) To furnish such jigs, fixtures and general facilities as will most expedite the work.

(c) To supply the proper kinds and amounts of material at the exactly proper times and places.

(d) To give expert instruction in methods and processes; these instructions to be as detailed and as much matters of course, as the drawings issued by the designing engineers.

(e) To scientifically determine under the foregoing conditions, what production the man should attain; and, finally,

(f) To reward the man in proportion to his degree of attainment of this ideal standard.

The standard of production fixed under (e) is never to be changed unless standard methods, tools or processes are changed. Here is the sharp contrast with pure piece work. The standard of production with the latter was established by a guess (usually based on the workman's previous performance), and the employer demanded the privilege of making repeated guesses. Under the profit-sharing systems, the aim is that this standard shall be accurately ascertained; if it is not, these systems lose one of their psychological advantages over piece work. Not the whole advantage, however, for in the very process of setting the standard rate the employer's attention will have been caused to dwell on the momentous question of fixed charges.[2]

As an example, suppose the fixed charges, reduced to their

[1] This phrase is here used in a sense technically incorrect: not to describe those philanthropic and paternal schemes exemplified by the employees' stock-sharing scheme of the United States Steel Corporation, but (in default of a generic word) as covering all forms of 'bonus," "premium" or "efficiency" systems of wage-payment.

[2] But it may as well be remarked here that in the writer's opinion the profit-sharing systems are weak in their psychological foundation. Unlike a steam engine, a man has no clearly defined maximum efficiency. We can never safely predict what a human being can do. Proposition (e) seems therefore one that cannot be definitively realized.

proportion per employee, to amount to $4.00 per day: the workman producing, under day work, 20 bolts, with a wage of $2.00. The total cost per bolt is 30 cents. On piece work at an 8-cent rate and a production of 30 bolts, the fixed charges are still $4.00, the workman is paid $2.40, and the cost per bolt is 21.3 cents. Both man and employer should be satisfied.

Now, as in the previous illustration, suppose the workman to produce 50 bolts in a day, for which he receives $4.00. The total cost of $8.00 per day now amounts to 16 cents per bolt. Apparently both man and employer should be better satisfied still. And so they should be; so perhaps they would have been if both had looked at the subject in all of its bearings. But since piece work is supposed to be a labor saving device, the exorbitant type of employer cuts the rate to 6 cents, making the total cost per bolt (with a 50 bolt daily production), 14 cents. He has thus made a little further gain—but he has probably killed the goose that laid the golden egg; and piece work falls into disrepute.

The employer could in reality have well afforded to pay a rate equivalent to the old day labor cost of 10 cents per bolt; this would have led to the following results:

Daily production	Paid to workman	Total cost, including fixed charges	Cost per bolt
20 (day work)......	$2.00	$6.00	30 cents
30..................	3.00	7.00	23 1/3 cents
40..................	4.00	8.00	20 cents
50..................	5.00	9.00	18 cents

On this basis the workman would have had no possible ground for complaint. The trade union might have had, if it were one of those unions which preach the restriction of production; this is a matter which must be looked into in detail presently. The employer, on the other hand, should have no fault to find. True, the workman is getting full benefit from an increased production toward which, at some pains and expense, the employer has provided the incentive. The former is not, perhaps, entitled to all, and the profit-sharing systems undertake to decide what part he is entitled to; but the figures show that as compared with day work, in cases where fixed charges are a serious factor, the employer would profit richly even if he had to give the workmen all.

There is here, then, a gain due to the incentive provided; a gain due to the extra effort of the workman; and a third gain, working while all parties sleep—almost—in the reduced rate of fixed charge.

The Halsey Premium System

This is perhaps the oldest of the accepted plans of profit-sharing. It is the one probably in most general use in machine shops. The workman is guaranteed his full day wage, regardless of production. Under the piece work system first described, if a man produced 20 bolts (as under day work) he earned only $1.60 instead of his former $2.00. Under the Halsey system he would still get the $2.00. Thus far, the plan gives a sop to the laborer and thus disposes of one of the more elementary objections to piece work.

But now, suppose the man to produce 30 bolts in a day. Under the old day work basis, this would have required 1 1/2 days. If paid at a piece rate equivalent to the former day rate, he would receive $3.00 for his day's work. He has saved half a day as compared with his former record. Under the Halsey plan. he is now paid *one-third* (or generally from 25 to 50 per cent.) of the value of what he has saved, *i.e.*, for 1/6 day's time; or 33 1/3 cents, *as a premium*, making his compensation for the day $2.33 1/3.

Two points should be noted; the basis on which the bonus is computed is the *previous record of the man;*[1] and the saving in time is so divided that the employer and the employee each get a share. As to the first point, there is no reason why the standard performance should not be based on a scientific study, as in more fully developed systems. If this were the case, the system would be more satisfactory. As to the division of profits, no hard and fast rule can be laid down. Under piece work, the employee gets all of the benefit from the time saved, although to accomplish this saving he has driven machines harder, consumed more power, etc. It would seem that the employer is entitled to part

[1] Previous records are regarded in much the same way as athletic records. It would probably be safe to assume that no man in the world could run a hundred yards in much less than ten seconds!

of the benefit; and by giving him a part we reduce his temptation toward a cutting of rates.

How this principle works out may perhaps be shown more clearly by the following figures:

Daily production	Time saved, based on a normal production of 20 bolts per day	Workman's share of time saved	Workman's wage	Workman's wage per bolt	Total cost per bolt[1]
10	....	....	$2.00	20 cents	60 cents
20	....	....	2.00	10 cents	30 cents
30	½	$.33⅓	2.33⅓	7.8 cents	21.1 cents
40	1	.66⅔	2.66⅔	6.7 cents	16.7 cents
50	1½	1.00	3.00	6.0 cents	14 cents

We here note that the workman's daily wage steadily increases as his production increases, though not as rapidly as under a pure piece work rate, because the *wage per bolt steadily decreases as the production increases.* The total cost per bolt (the thing that concerns the employer) also steadily decreases. These features are not peculiar to the 2:1 division of profits; they are characteristic of the system for all possible ratios of division.

The gist of the matter lies here. It is the interest of the employer that the total cost per bolt shall be a minimum; therefore, also, that the number of bolts produced shall be a maximum. Is the incentive toward maximum production sufficient when the workman receives less per piece, the more he produces? In many cases, no; but no absolute answer can be given, because it is the day's earnings which after all count with most men. Yet it seems hard task-mastery to bait men on to efforts continually more strenuous and as continually less profitable.[2]

[1] Fixed charges constant at $4.00 per day.

[2] The Halsey plan makes no pretence to a "scientific" character in the current sense. No standard methods are contemplated; the workman is left undisturbed to increase his productiveness in his own way. The system may be introduced with practically no friction or disturbance.

In Rowan's modification of the Towne-Halsey system, provision is made that the workman shall be unable under any circumstances to more than double his earnings. Thus, let A be the standardized time for a job, B the time actually consumed by the man; then the percentage of time consumed for which the workman is paid a premium is

$$\left(\frac{A-B}{A}\right)$$

if B = A/2, he is paid a premium for *half* the time consumed, so that his hourly rate increases 50 per cent.; if B = A/4, his hourly rate increases 75 per cent.; but it can never increase to more than double. If B = A, there is, of course, no premium.

THE DIFFERENTIAL PIECE RATE SYSTEM

To bring this point out clearly, let us consider a system in which because of high fixed charges (due to the use of expensive machinery) it is profitable not merely to keep up the wage per piece, but actually to increase it as the production increases. Here we have a *differential piece rate system* in which the workman is given the value not only of all the time he saves, but more.

Let the day's production be standardized at 20 bolts, the day wage be $2.00, and the compensation adjusted so that the man is given 1 1/2 times the value of the time he saves: fixed charges applicable being in this case $12.00 per day. We then have:

Daily production	Time saved, based on a normal production of 20 bolts per day	Workman's compensation for time saved	Workman's wage	Wage per bolt	Cost per bolt, including fixed charges
10	....	....	$2.00	0.20	$1.40
20	....	....	2.00	0.10	0.70
30	½	¾ = $1.50	3.50	0.11⅔	0.51⅔
40	1	1½ = 3.00	5.00	0.12½	0.42½
50	1½	2¼ = 4.50	6.50	0.13	0.37

Here the workman's wage per day runs very high, because his wage per piece increases with his production. His recompense varies not directly, but as some power of his productivity. Meanwhile the cost to the employer per piece steadily decreases. Under the Halsey system, as previously described, it would have been about 30 cents, instead of the 37 cents here tabulated, for a production of 50 bolts per day. It is a fair question whether under the assumed conditions a 50-bolt daily production, with the accompanying differential rate wage of $6.50 would not be far more likely of realization than a 40-bolt production at a Halsey wage of $2.66 2/3. The total cost per bolt would be about 37 cents in either case.

Suppose such production to represent so high an attainment that only the best men, under the inspiration of the highest incentive, will reach it. The incentive of a day's wage of $6.50 may be assumed to be just sufficient. Suppose also that under the much lower wage scale of the Halsey system the production reached was only 30 bolts per day, at which the day's wage would be $2.33 1/3 and the total cost per bolt 48 cents, nearly.

The employer would be much worse off, obviously, than if he had paid $6.50 as the day's wage and in so doing have reached the total unit cost of 37 cents. The workman is worse off by $4.16 2/3 per day than he would have been under the differential piece rate; but he had no opportunity at this rate; his loss, as he views it, is merely the difference between $3.00—the maximum under the Halsey system—and $2.33 1/3, or 66 2/3 cents, a loss which he may regard as endurable since he works only 60 per cent. as hard as he would have to work to eliminate it.

Based on the figures selected, then, the employer must decide whether he will pay the workman $6.50 per day instead of $2.33 1/3, in order to secure a unit cost of 37 cents instead of 48 cents. Will he give the man $4.16 2/3 in order that he may save $5.50 over and above what he gives the man? Most people would if they approached the subject in a cool and rational manner, but of course the proportion of fixed charges has in this illustration been purposely made high.

The characteristic of the differential rate system (introduced by Mr. F. W. Taylor) as thus illustrated, is the existence of two (or more) distinct piece rates. (Mr. Taylor uses only two.) The low rate is paid for low production, the high rate for high production. This is the directly opposite plan to that of Mr. Halsey. In the absence of a guaranteed daily wage—a characteristic not shown by the tabulation—the differential plan also differs from Mr. Halsey's. It gives the workman *more* than his "share" of the benefit from increased production. In the table, for example, an increase in production of 25 per cent. (from 40 to 50 bolts per day) raises the daily wage $1.50 or 30 per cent.

The Gannt Bonus Plan

Thus far the workman's additional compensation has come to him as a payment for time saved, bearing some relation to the amount of time saved. In the Gannt bonus system, the reward on the contrary took the form of a definite prize for a definite achievement. This system was perhaps the first (of those now under general discussion) in which an earnest effort was made to determine how much time a job should take, regardless of previous average performances. The same effort is made, however, in the more recently discussed differential rate system.

Suppose the day-worker producing 20 bolts at a daily wage of

$2.00 to be put under scientific observation, as a result of which it is concluded that a proper day's production is 30 bolts. He is now offered a *bonus*, which may be any sum of money whatever, under the condition that he produce 30 bolts. If he produce 29, he receives his hourly wage, but no bonus.[1] If he produce 50 (which is unlikely, because careful study has shown a production of 30 bolts to represent genuinely good work), he receives the standard bonus, but no more. Let the bonus be $1.00[2] and the fixed charges $4.00 per day, giving the following results:

Daily production	Bonus	Workman's wage	Wage per piece, cents	Total cost per piece, cents
10	....	$2.00	20	60
20	....	2.00	10	30
30	$1.00	3.00	10	23⅓
40	1.00	3.00	7½	17½
50	1.00	3.00	6	14

The bonus system is claimed to be one that can be readily introduced without friction, particularly (when the bonus is fairly high) as a step forward from piece work. An essential feature is that standard methods and instructions are provided so that the workman may feel that he is being helped to earn his bonus. These may cause friction. The piece work pitfall—excessive earnings by the workman—is avoided.[3]

But the plan discourages individuality. The workmen are grouped into two grades only, the bonus-earners and the non-bonus-earners. There is no opportunity for each man to do his individual best, no premium on distinction, no reward for the passably good man. The Halsey and Gannt plans are in this respect diametrically opposed.

These defects may be in part remedied by the device of "standard time." Instead of standardizing production at 30 bolts per day, we will standardize time at the equivalent: 1/30 day per

[1] The present day's wage is guaranteed.

[2] The bonus usually ranges between 20 and 50 per cent. of the previous day's wage.

[3] Curiously enough, it is claimed that a change in standard rates under the Gannt system is possible without the disturbance which such a change is sure to create in a piece work shop. The Gannt standard is a *time* rate, so that when a change is made it is technically one in *time*, not directly one in *money*.

bolt. Let us agree to pay the workmen 1/30 of a day's wages—6 2/3 cents—*for every bolt he produces, providing he produces* 30 *in a day.* The system then becomes pure piece work excepting for its minimum provision—the production of 30 bolts per day; and since the presence of any man who produced less would be unsatisfactory to both man and employer, such men would soon be weeded out and the system would become piece work pure and simple.

The bonus system is frequently applied to gang work, where the men (and often their foreman as well) receive a bonus conditionally upon the completion of the prescribed gang task within the standard time. The *contract system,* found in large works, involves either a gang piece rate or a gang bonus. Even the higher shop officers are in some plants given a bonus as a reward for realization of some set standard of performance by the whole department or works. A contract rate may be accompanied by piece work or bonus rates for the men working under the contractor; or their men may be straight day workers, having no share in the profits which the contractor derives from their labor.

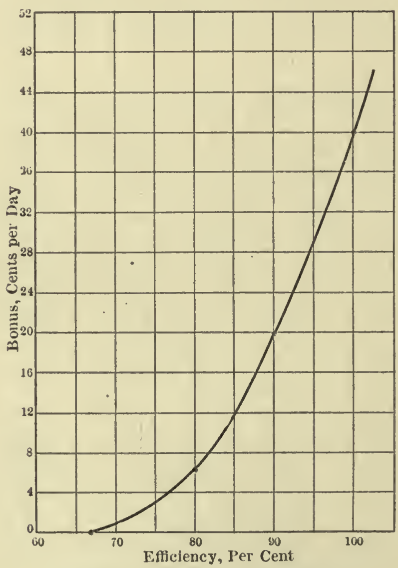
The Emerson "Efficiency" System

This last of the systems is a development from both the bonus and the premium plans; combining good elements of both, and recognizing the human element by giving, within reason, a tempting incentive to every man to do his personal best. Mr. Going has given the striking illustration which compares the Halsey plan with an inclined plane, that of Gannt with a precipice up which the workman must jump, and that of Emerson with a hill of gradually increasing steepness.

The "efficiency" scheme may be illustrated from the same data as the other systems: day wage $2.00, production 20 bolts, fixed charges, $4.00. Let the standard production be set at 30 bolts (=100 per cent. efficiency) for which a 20 per cent. bonus (40 cents) is given. For a production of 27 bolts (27/30=0.90 efficiency), the bonus will be 10 per cent., or 20 cents; for 24 bolts (24/30=0.80 efficiency), it will be 3 1/4 per cent. or 6 1/2 cents; falling to no bonus at 66 2/3 per cent. efficiency or a 20-bolt daily production. (A curve is plotted to show the rate of bonus for each rate of production.) The present daily wage is guaranteed. For an efficiency of 120 per cent. (36 bolts per day), the bonus is 40 per cent.—80 cents—and so on: the higher the efficiency, the higher the bonus. This leads to the following results:

Daily production	Daily wage	Wage per piece, cents	Total cost per piece, cents	Efficiency
20	$2.00	10	30.0	0.6667
24	2.06½	8.6	25.2	0.8
27	2.20	8.1	23.0	0.9
30	2.40	8	21.3	1.0
36	2.80	7.8	19.0	1.2

Here the equivalent piece rate falls off somewhat as production increases; the total cost per piece might be reduced even if no such falling off were contemplated.



Relation Between Bonus and Efficiency.

Remarks

In all of the systems, excepting the pure differential, the workman is guaranteed his present daily wage: the plan is to share profits, but not losses, with him. He is not, however, guaranteed continuous employment should he fail to reach the standard of performance desired.

Care should be taken not to make comparisons or draw conclusions from the tabulated figures which are accidental rather than essential. For example, if the curve on page 42, showing the relation between efficiency and bonus, were differently drawn, the costs per piece and wages per day would all compare differently with those under the other systems described. With almost every system, there is an endless variety of definite compensation scales possible.

Just what the scale should be is always a nice problem. The writer's sentiment in the matter is that it should be liberal to the workmen; one in which a doubling of present earnings may be a realizable possibility. There are of course some business conditions under which this would be impracticable. But in general, a highly profitable business ought to pay its workmen handsomely —to give them a share. Intensified production is the most highly profitable industry we know of. Let us therefore be generous with the man whose coöperation we must have in order to make that industry succeed, and give him a *big* share in the profits. Mr Taylor, however, finds that an increase exceeding by more than about 60 per cent. the present wage scale is detrimental to the steadiness of the men. Perhaps a sudden increase in salary of 60 per cent. would have bad effects on any of us! Business, we are told, is war; but if wages and profits can be increased together, where is there adequate ground for belligerency?

Labor management is thus attacked as a psychological problem. A "measuring-stick" is provided, one that is "definite, accurate and fair," by which each man's individual performance is to be judged. Conditions must be such that, as far as possible, all modifying factors shall be eliminated, and that the man's output shall depend wholly upon himself.

This last stipulation is often difficult of realization, sometimes impracticable. The workman then "takes his chance" and he will in the long run win, if the conditions have been fair. In a large mill power plant, for example, it was found entirely satisfactory to pay a prize to that gang of firemen which had during the stated period burned the least fuel, regardless of all modifying conditions whatever. The wrong men sometimes won; but in the long run the prize money was distributed about in accordance with merit.

Mr. Gannt regards the determination of scale of payment as only one of three essential elements in the development of a profit-sharing system; the others being the ascertainment of the proper day's task and the planning for continuous efficient work.

To make a man's earnings depend upon his proficiency elevates rather than lowers him in the industrial scale. To impose a tacit penalty for inefficiency dignifies those who are efficient and gradually eliminates the unfit. A continuous record of the efficiency of each man[1] becomes as essential to the manager as a Babcock tester is to the dairyman who cannot afford to maintain an unprofitable cow. The whole series of such records tells the degree of efficiency of the management.

The new school of labor management has for its immediate aim a tripling of the labor-hour production at a 20 to 100 per cent. increase in daily wage. The first two years with the modern methods at the Topeka railway repair shops are authoritatively stated to have resulted in an average increase of pay of 14 1/2 per cent., an increase in output of 57 per cent. and a reduction in cost of 36 per cent.

Profit-sharing as a Management Problem

The introduction of these systems should now be considered from another standpoint than that of costs—from the immediate standpoint of the shop supervisor. Their most fundamental feature in this respect is the prescription of method and tool by and with which the workman is to do his work.

The concession has been made that a boss need rather know how a thing should be done than be able to do it himself. But now, someone in authority must not only know how—he must know how infinitely better than any of his men—but he must also if necessity arise, *show* how. We thus have the modern ideas of the tool-room staff and the testers. These men, experts in their particular kinds of work, determine definitely the best tool and the best method to be employed for each operation.

In order that the reward to the man may appear as an addition

[1] It has been stated that the older men, in the machine shops, uniformly do better under profit-sharing wage-systems than the others.

to his present daily wage, time and cost must be determined for both present conditions (by observation) and for proposed standardized conditions (by calculation, experiment and observation). The steps in the study have been presented in the following order:

1. Devise a method for determining present expenditure of time on a particular piece of work;
2. Make such improvement in conditions as can be effected readily, and may reduce the expenditure of time;
3. Determine the elements of time and cost, as for
   a. Handling the raw material,
   b. Setting up the work in the machine,
   c. Machining, and
   d. Removing the finished product;
4. Determine what expenditure of time and cost would be necessary under ideal conditions as to all four elements, checking conclusions by experiment, if necessary;
5. Establish the scale of "bonus," "premium," or "efficiency" payments;
6. Guarantee the present wage (?) and establish a basis for a bonus to foremen, etc.

If the bonus scale has been carefully worked out, it may be safely predicted that the workmen as a whole will realize or improve to some slight extent on the standard time expenditure ascertained under (4); and some enthusiasts even go as far as to contend for the use of these "standard" rather than of actually observed time rates in estimating on new work.

In the study of time consumption, various aids like the stop watch, invisible watches inserted in the note-book, mechanical time recorders, etc., are employed. Cut meters are used in the machine shop for determining cutting speeds on machine tools. All original "time study" records are carefully filed for future reference.

The "testers" are men employed to experimentally create time records for performing standard operations; they constitute a force working by themselves in a locked room, independently of the shop foreman. The "speed boss," in a staff-organized shop, has jurisdiction over cuts, feeds and speeds of machine tools, specifying such as are proper for the material at hand and the accuracy and finish desired. He sees that tools are standard and set in the standard way, and prescribes as to the use of cutting oils, soaps and compounds. He may have jurisdiction over belts and belt speeds, and will in any case insist on good condition of machine driving belts.[1] He is the man who will surely discover the badly-manned department. In a shop making small machined parts, the force of 63 men was reduced to 22 men within one month after the advent of the speed boss.

Three elements in operation have been emphasized as a result of recent time studies. The first of these is the material "despatching" element. To get materials and tools to the man when and where he needs them is an important matter. Under day-work organization, any delay in this respect gave the man an excuse for low productiveness. Now he wants no excuse and resents delays. An adequate system and proper facilities for the interdepartmental despatch of new and finished materials is now at least as important as a power plant. "Lost motion" must be eliminated; materials and tools are brought to the workman by lower-priced labor; a program or plan is provided so that at any hour each item of material or equipment shall be where it is needed and not elsewhere. The old-fashioned grindstone—the village tavern of the shop, gathering place for gossip and recuperation—is a thing of the past.

Marked improvement in productivity has been realized in erecting and assembling machinery; and in such work despatch is of particular importance. Failure of a boy to drill one hole may delay a large gang of men a long time.

Tools must not only be at hand when wanted, they must be conveniently at hand, placed where accessible and where they can be easily identified one from another, and they must be supplied in excess of probable requirements. The same stipulation applies to material to be used, and the proper devices for handling that material must be concurrently available.

A second factor now strongly emphasized is the setting up of work. With many machine jobs, a large proportion of the total time is consumed in getting the piece in the machine. Experience has shown that a saving of 30 to 50 per cent. is possible in this respect by scientific improvement of conditions. Thoroughly suitable jigs and chucks should be standardized for the various classes of work, and the variety of makeshifts which accumulate about the average shop should be inexorably scrapped. All

[1] In one instance, attention to these matters reduced the cost of belt maintenance 74 per cent., *while simultaneously decreasing belt failures by* 68 *per cent.*

clamping devices for hand work on the assembly floor and elsewhere must be interchangeable, and the system for serving the workman with tools should also supply him with setting-up equipment. The tool-room experts and time-study men will determine as to the proper time allowance for setting up work. In some shops, the regular men simply run the machines, a special set of men being charged with the work of placing the material in the machine.

A third feature of the modern system is in the inspection. Material transferred between departments, if defective in any respect which may impair the recipient's productivity, will be sure to have its defect exposed: but if the fault is not of this kind, no such result may follow. Product leaving the last hand for the consumer may need especially rigorous inspection under intensified production conditions. Tools, gages, and templates furnished the workman may also require such special inspection.

On the whole, the modern systems necessitate a more detailed and rigorous system of inspection of work passing between departments, and of finished work, than did older systems of management. Mr. F. W. Taylor gives an interesting example illustrative of this point, in connection with the inspection of bicycle balls in a shop where this very work of inspection was changed from a day-rate to a piece-rate basis.

An opponent of intensified production systems would certainly regard inspection as the very last kind of work in which a profit-sharing system of payment could be applied. About 120 girls were employed in this instance, to inspect an annual output of many millions of these balls, each of which had to be examined individually for dents, softness, scratches, and fire cracks. The girls were skilled in the work, which had been regularly carried on for eight or ten years.

"The first move before in any way stimulating them toward a larger output was to insure against a falling off in quality. This was accomplished through over-inspection. Four of the most trustworthy girls were given each a lot of balls which had been examined the day before by one of the regular inspectors, the number identifying the lot having been changed by the foreman so that none of the over-inspectors knew whose work she was examining. In addition, one of the lots inspected by the four over-inspectors was examined on the following day by the chief inspector, selected on account of her accuracy and integrity.

"An effective expedient was adopted for checking the honesty and accuracy of the over-inspection. Every two or three days a lot of balls was especially prepared by the foreman, who counted out a definite number of perfect balls, and added a recorded number of defective balls of each kind. The inspectors had no means of distinguishing this lot from the regular commercial lots. And in this way all temptation to slight their work or make false returns was removed." (*Trans. A. S. M. E.*, XXIV, 1383.)

Following this plan of insurance against deterioration in quality of work, accurate daily records were started of the quantity and quality of output of each girl. The scale of day pay was readjusted on the basis of the information given by these records. Detailed time studies were made. Talking while at work was stopped by separating seats. The day's work was reduced from 10 1/2 to 8 1/2 hours, with two 10-minute recesses allowed each day. A differential piece rate was then introduced, not for high output (a definite standard output was established) but for greater accuracy in inspection as determined by the over-inspectors. The force of girls was reduced from 120 to 35; average weekly wages increased from $3.50 or $4.50 per week up to $6.50–$9.00. There were 58 per cent. more defective balls sent out under the old day work system than under the new plan.

The Introduction of Profit-sharing Systems

Here careful planning and diplomacy are needed. The thorough reorganization of an existing works along modern lines may be a matter of two to five years. Nothing can be gained and much will certainly be lost by undue haste. The system should be installed gradually and made to justify itself to owner and employee as it progresses. The right man must be selected to introduce such a revolutionary change as profit-sharing involves: "none but Ulysses can bind Ulysses' bow."

In an engineering works, the improvement may well begin at the drafting-room. A chief draftsman of progressive type, preferably one having had shop experience, should apply it to his own work. Intensified production[1] is by no means inapplicable to drafting and clerical work. One of the first steps is to abso-

[1] Even the typewriting of letters has been paid for on a premium basis. In one office, the statistical work was thus organized, curves of the type described in Chapter III being drawn by men whose time expenditure for performing the calculation, marking the point and drawing the line was standardized at 200 such complete operations per hour.

lutely eliminate "designing in the shop" by making all drawings, sketches and instructions unusually definite and complete. In most plants this would mean a considerable increase in expenditure in the drafting room—an increase which is, however, unquestionably profitable.

This must be faced cheerfully, and the chief draftsman given such assistance as may be necessary to afford him time and energy for betterment work. Much preliminary planning in standardizing parts and products will also be necessary. A more thorough study of designs with relation to facility and cheapness in construction and erection will be undertaken.

Regular meetings of officials to be concerned in the reorganization will be inaugurated. At these meetings there will be free criticism and discussion, and the old idea of territorial sovereignty on the part of departmental foremen will be seriously modified. No man will be expected to proceed thereafter on the basis of his own unsupported judgment. The standardization of shop methods under the general supervision of such a shop committee will be finally entrusted to a properly qualified subordinate staff.

Objections to Modern Labor Systems

Approval of the methods described in this chapter is by no means unanimous, even among managers. It is urged that they involve the assumption that a setter of time rates can be infallible; that "all the brains are in the office"; that a machine operator is presumed to have no original ideas of time or money value. The workman is not encouraged or expected to improve on his instructions; such improvement is in fact often positively discouraged.

There is ground for these objections, and the advocates of profit-sharing systems have not absolutely refuted them, perhaps because they have been too busy at more profitable enterprises. Yet if the modern method is what it is claimed to be, no expenditure of time in convincing the industrial public of that fact is too much to contemplate.

The root objection is one that resolves itself into a question of pure fact. Can the combined capacity of a man and a machine be determined? Absolutely, perhaps not; nor is it necessary that it should be. The modern system aims to determine that capacity within a known reasonable margin of error: the old piece-work system virtually made no effort at all to determine it. It guessed.

The rate-setter is not infallible. He may make mistakes; these can be corrected. He may never—is never—exactly right; but he can be nearly enough right to reach the desired result, the setting of a standard of performance which shall permit of a wage scale remunerative to all parties concerned.

While the idea of task-work under instructions is fundamental, this should eventually be no more objectionable than the prescription of an apparently awkward method of holding a cold chisel is to a "green" apprentice. Under the modern systems, all of the workmen must learn over again how to do certain things. For the time being, they again become apprentices. If the new ways of doing things are not better ways they will surely be abandoned.[1]

There can be the same incentive offered for improvement as under the old day work system. The man whose ideas are valuable will never be discouraged by a sensible supervisor. The new school merely prescribes that the man shall learn and perfect himself in the prescribed method first. When he has attained the standard result, if he then believes a better result to be possible, his scheme should be tried, honestly tried; and, if it prove good, it may become the standard.

But what is to be the effect of the new methods on the supply of skilled workmen? Already in certain trades the all-around journeyman has practically disappeared. The specialization which surely accompanies standardizing and intensified production will accentuate this condition. Trade apprenticeship is becoming uncommon. The limitations imposed by the labor unions, the unattractiveness of a long apprenticeship to the average boy, the opportunities for entering avocations deemed more honorable or profitable than that of the manual worker—al of these causes are reducing the "birth rate" of skilled workmen.[2] Ordinary laborers may qualify for the economical performance of repetitive work; they may even by a process of

[1] Mr. Gilbreth's *Motion Study* goes into the matter more deeply still; he analyzes not merely *methods*, but *motions*, physical movements, in their anatomy and combinations.

[2] It has been stated that only 10 per cent. of the boys who become apprentices in machine tool building plants "serve out their time." No doubt a factor in this falling off is the exploitation of the boys by their foremen; they are put on special work where their time is spent with profit to the employer but without much benefit to the apprentice. The boy's future prospects are sacrificed for the present gain of the "boss."

natural selection produce from among themselves the necessary experts and foremen. Trade schools cannot begin to supply the demand for skilled men.[1]

[1] **Apprenticeship.**—An apprentice is a pupil or learner who enters into a contract with an employer, under which he gives his services in return for his training in the trade plus a (usually small) wage. The term of the apprenticeship contract or *indenture* has steadily decreased. It was once seven years; three years is the usual time at present. The philosophy of the system may be illustrated from the writer's personal experience. He was apprenticed at an hourly wage of 5 cents for the first year. This was to increase to 7 cents the second year and 10 cents the third. During the third year, if the boy was worth anything, he usually became as active a producer as the "laborer," who received from the start 15 cents an hour, but was given no educational opportunities. But whereas the laborer could never hope to make more than 15 cents (excepting under most exceptional circumstances) the apprentice, as soon as his three years had expired, received 20 cents an hour. Piece work put an end to this (already antiquated) system about 1893.

From the time of the guilds of the middle ages, there existed a sentiment that the trades and the public must be "protected" by forbidding the practice of a trade excepting by those men having served a specified apprenticeship. There were laws to this effect. Arbitrary division lines between the trades were introduced, with the same embarrassing consequences as exist in the building trades in New York City to-day.

The great economist, Adam Smith, advanced some ideas on this subject that would even now be regarded as novel. He claimed that long apprenticeships were unnecessary; that a few weeks should suffice to teach an intelligent person a manual trade. He proposed paying to the apprentice full journeyman's wages, with deduction for spoiled work (perhaps a forecast of the bonus system), claiming that this would develop habits of efficiency and that the whole trend of the then existing systems of indenture was toward monopoly.

Mr. O. M. Becker (*The Engineering Magazine*, November, 1906) states three reasons for the present failure of apprenticeship systems:

1. Greed of foremen who work the boys for immediate productiveresults.
2. Loose verbal agreements.
3. Lack of encouragement and instruction.

Mr. Becker recommends the appointment of a supervisor of apprentices who shall correct these conditions and keep in personal touch with the boys. Carefully worked out apprenticeship systems are in vogue in the works of the Brown and Sharp Mfg. Co., R. Hoe & Co., the Warner and Swasey Co., the Allis-Chalmers Co. and the Westinghouse Electric and Manufacturing Company. A digest of these calls attention to the following factors:

Age Limit.—At start, in one instance, from 17 to 21 years; or (in most cases) a grammar school education; reduction in term of indenture, sometimes, for boys having had more schooling.

Term.—Three to four years seems to be the desired ideal. This may be reduced, it is agreed, if systematic instruction is included in the plan. Neither term nor wage has any apparent influence on the supply of boys.

Wage.—In one case, 4, 8, 9, 12 cents for the four years. The premium system is sometimes applied. One writer concedes that 8 cents is too low a wage.

Inducements.—A bonus (usually $100) is sometimes paid to those who complete their term. Tools are occasionally furnished by the employer. Cheap boarding places may be provided.

Education.—The factory school is an occasional adjunct, instruction more or less systematic being given by heads of departments. An allowance of time may be made for study Sometimes boys are required to attend night school outside, with or without such time allowance.

In the Baldwin Locomotive Works, Philadelphia, three forms of indenture are used:

1. For boys of 17 or more, having had common school education, who are bound to serve four years, and who agree for three years to attend night school for the study of algebra, geometry and drafting. Upon satisfactory completion of this service, a bonus of $125 is paid.

2. For boys of 18 or more, who have had advanced grammar or high school training, who will agree to attend night school for two years for the study of drafting. These are bound for three years and receive a bonus of $225 upon completion of indenture.

But it is unfair to attribute the scarcity of trained men at the present moment wholly or even in any large measure to the specialization of profit-sharing systems, for these systems have not yet come into general application. The causes for this scarcity would exist (in this country) anyway. And on the whole, is this scarcity altogether a bad sign? It would seem that Mr. Gilbreth's suggestion for a reclassification of the trades is justified from a consideration of the matter. Instead of having expert machinists and expert bricklayers of all-around ability, we

3. For graduates of technical institutions, 21 years of age. These serve two years under agreement and the works is obligated to teach them the mechanical art. They receive no bonus.

In all cases the works retains the right to dismiss for cause. About 33 per cent. of all apprentices entering have been so dismissed.

TABULAR STATEMENT (1906)

	Class 1	Class 2	Class 3	Total
Total number enrolled since 1901	471	224	117	812
Number enrolled in 1904				59
Number enrolled in 1905	95	76	31	202
Number now on roll				405

DISTRIBUTION OF 1905 ENROLLMENT

Machinists.............169	Blacksmiths.............4	Sheet ironworkers........2
Molders................ 2	Boiler makers............9	
Brass finishers.......... 7	Pattern makers..........9	

Of the present enrollment, 36 apprentices are from foreign countries.

Of the apprentices enrolled and graduated since 1900, five are now foremen, one is in the main office, one is assistant engineer of tests, three are assistant foremen, one is a contractor, 24 are erecting shop track bosses, 6 are employed on special work, and a large number of the remainder have desirable piece work jobs. Of the 41 men specially mentioned, about 20 are from Class 3, the others being about equally divided between Classes 1 and 2.

Comments.—Engineer-managers, as trained men, should believe in trained men and should therefore favor those who have at some sacrifice elevated their standard of serviceableness. But the present ideal of apprenticeship and the present conception of scope in the trades seem likely to be altered.

A boy cannot do a full day's work and study besides. Every boy in these days should have at the very least a grammar school training. The education in algebra, geometry and drafting that he needs to make him a first-class workman should be furnished by the shop in shop time. Terms of apprenticeship should be further reduced by training boys more systematically. It should be possible to make such terms vary inversely as the amount of schooling the boys have had.

Wages are too low. The boys should be self-supporting from the start. An increase in bonus for completion of the term should be preferred, however, to a great increase in wage scale. Too much of an increase in this latter direction would be bad on several grounds. The provision of good board at a reasonable rate would help out the financial difficulty

Wages and terms must vary in different industries and in different sections of the country. The most promising boys to cultivate are the country lads, having homes not too far from the manufacturing cities.

may two or three generations hence have expert men in the different phases of these trades; an expert tool grinder, who could scarcely chuck a bar; an expert face bricklayer who could not set up an arch, etc. Trade apprenticeship would then be regarded as unnecessary, a waste of three or four years' time at nominal wages which modern conditions will have made it possible to dispense with.

Instead, boys (or men) will learn with great rapidity how to perform some special operation in the trade, attaining a scale of daily wage now not reached by the most expert of the "all-around" men, because of their vastly higher productiveness.

The Effect on the Workman

In the discussions of the past few years regarding improved agricultural methods, the question is sometimes asked, "What if everyone did so?" If all farmers should tile-drain, irrigate, rotate crops, grow clover, and spray fruit, would not the increased reward now obtained by the few who do these things disappear? And similarly, if the workman's production is generally tripled, will not the action of competition and of the laws of supply and demand bring about a gradual lowering of the daily wage again to its present level?

Two suggestions may be made. In the first place, not all farmers will practice scientific agriculture—not at least for generations to come. Nor will manufacturers generally practice scientific management. There are only a few in every industry who use the best methods; and to these few the large profits are awarded. The workman who increases his individual productiveness *now* will for a long time to come be in a superior position to the mass of workmen.

And there is an argument still more fundamental. We in this world have just two things to do: to produce all we can, and to obtain a just share of what we produce. The first thing is the economic subject of *production*, the second suggests the economic topic of *distribution*. Nothing can be distributed until it is first produced. The more that is produced, the more there will be to distribute. In the last analysis, all of the wealth in the world comes from human sweat, from the labor-hour. Whatever increases the labor-hour production augments the supply of wealth, increases the visible assets of the world. There can be no harm in this. Other things remaining equal, the more we produce, the more we shall obtain. If bad economic conditions temporarily interfere with this, the remedy is to improve those conditions, certainly not to decrease production.

Money does not measure cost or value. The blacksmith of King Arthur's age earned a penny a day, but that penny might feed him for a week. The ultimate measure of value is the labor-hour. The ultimate determining factor in the available supply of the good things of this world is the labor-hour output of the average man.

[Perhaps the best-known application of the methods described in this chapter has been in connection with the betterments in the motive power department of the Atchison, Topeka and Santa Fe Railroad. A bibliography of the publications dealing with this enterprise was printed in the *American Engineer* in October, 1907.]

CHAPTER V

Material

Economy in manufacture is related to materials consumed in the following ways:

1. These materials must be secured at the minimum possible cost for the necessary quality. In buying coal, for example, the number of thermal units obtained for one cent is the chief basis for comparison.

2. The kind and quality of material must be such as will: *a.* Involve the least expense in fabrication, and *b.* result in the most valuable product.

For example, flaxseed which had become wet might be secured at a very low price considering the oil which it contained, but might nevertheless be undesirable because of the great difficulty in handling and working the seed in the linseed-oil mill.

Again, rag stock is very costly for a paper mill, but a paper made from rag stock might sell for 15 cents a pound as against a 3 1/2-cent price for a paper made from wood pulp.

3. Material must be so employed as to obtain therefrom the greatest possible *quantity* of product.

4. Any necessarily discarded portion should be, if possible, profitably utilized.

5. Proper facilities and equipment must be provided for economically moving and handling raw, partly finished and finished materials to and through the works.

6. There must be an adequate system of organization for insuring that materials shall be at hand where and when wanted, without maintaining unnecessarily large stocks.

7. All expenditures for material should be ultimately charged against some item or unit of productive output.

These considerations may suggest the following topics as necessarily to be treated under the general heading of "materials."

Material costs and methods of cost finding.
Purchasing.
The function of the storeroom.
Economics of material utilization.

Cost-keeping System

When the term cost-keeping is employed without qualification, material costs are first thought of. And to know the cost even of materials consumed for each item of product is by no means easy. Most manufacturers think they know; some only guess. If a plant made only one thing at a time, and purchased each time just enough new material to make that one thing, it might conceivably obtain an infallible record of its material cost for producing that one thing. But all plants make many things at once and the purchase of material is often only indirectly related to the things to be made.

As with statistical records in general, a material cost system should not merely show the facts, it should give data for ascertaining the reasons for the facts. Such a system is a "tool" (to be kept in good condition) "for cutting down costs."

Managers have been sometimes known to profess indifference as to costs. They are making money, there is no competition, and that suffices. But even a profitable business may include some departments or operations which are unprofitable or relatively less profitable. These should be discovered. And a proper control of costs may enable even a profitable business to become more profitable, either directly or by permitting of increased output without expenditure for equipment. And finally, the piping times of peace are the times in which to prepare for war.

A material cost system must tolerate no "averaging," no grouping by departments. It must not ascertain the consumption and value of raw materials used by occasional computation or experiment. Its function is to ascertain

The Actual Consumption and Cost of Every Material Consumed for Every Item or Unit of Product.

This knowledge is necessary in order that selling prices may be intelligently fixed. It is also necessary for intelligent shop management. The system should originate with the inception of the works, but if the plant already exists, then it must be gradually installed. The larger items of cost—the "high spots" —are of course the first to be analyzed.

It is in the control of his costs that the superintendent or the department chief shows whether he is a mere routine man or a money-saver. If he is burdened with detailed clerical work that might be performed by cheaper men; or if his clerical assistance is of such character as to add to rather than detract from his anxieties—then he cannot be, in the fullest sense, a money-saver. And if he is sufficiently broad-minded he will recognize the fact that however much of a specialist he may be in his business there are outside men, expert not in his business but in the highly specialized business of reducing costs anywhere, who can do what he cannot. He should use, not oppose, such men. He should regard them as he does the real estate man or the lawyer—men whose advice he needs badly when he needs it; men of whose services he cannot afford to deprive himself. Some men there may be, among the "efficiency engineers," who are shysters; so also are some men in other professional fields.

Purchasing Methods

The purchasing agent is responsible for the money cost per unit of quantity and quality of goods received by the works. He has—or may have—four methods of buying:

1. Purchasing "over the counter," as when a woman at a grocery store pays the market price, presumably, for a dozen eggs.
2. "Shopping," as in the case of a prospective purchaser of an automobile, who visits several salesrooms inquiring for prices and finally acts when suited.
3. Ordering from price lists and discount sheets kept on hand for materials regularly consumed.
4. Contracting with the lowest (or otherwise most desirable) bidder on goods to be furnished to comply with stipulated specifications.

The importance of purchasing as one of the industrial operations varies greatly with the type of industry. In a process-industry, where some single raw material is subjected to a single simple process, as in flour mills, wood pulp mills, and some oil works, purchasing is the most important of all functions, and may be directly in charge of the chief executive.

In a "factory" (textile mill, machine shop, etc.), where labor is the chief element of cost, purchasing is less a matter of "close buying" in the ordinary sense than of expert knowledge regarding the relation between character of raw material and probable cost of fabrication. A machine shop which purchased all castings might, for example, do better when paying a fancy price for exceptionally workable castings than when receiving inferior material at a lower price.

In a public service corporation, the largest expenditures for material may be those made by the departments of construction and maintenance. These departments are officered by engineers, and the materials consumed by them are usually such as can be intelligently purchased only by men of technical experience. Consequently, arrangements for the purchase of such material are made by the department officials themselves, and this buying often constitutes, in fact, a chief part of their work.

It is in the ordinary "manufacturing business," like a paper mill or a chemical or engineering works, or a railroad, where many raw materials of comparable importance are consumed, and where the cost of materials is usually fully equal to that of labor, that the status of the purchasing agent is most firmly established.

The initial step toward any expenditure for materials is made when the purchasing agent receives a *requisition* from some department head. Nothing is ever bought except upon requisition from some one. This document will have a date, a number which may be referred to in any inter-departmental correspondence, a signature and an approval signature. It will state what is wanted, with full specification as to quality, quantity, and time of delivery required. It may have an acknowledgment stub, beyond a perforated edge, for return to the department in which it originated after endorsement with such information as may be proper. It should provide space for the buyer's notations as to quotations relevant, purchasing order number, dates of action, etc. The requisition remains a "live" document, and is kept in the "pending" file, until the purchasing order, which takes its place, has been issued.

Upon receipt of the requisition, the purchasing department may at once issue its purchasing order (if it is thoroughly posted at the moment on the applicable market prices) or it may send out to various parties with whom it deals its regular form of *request for quotation.* These may be in duplicate, the duplicate being printed on a stiff card for permanent filing after the requested quotation of price has been received and noted thereon.[1] Such records of prices will be consecutively numbered and filed and indexed daily, although original letters of quotation may be temporarily affixed to pending requisitions. Quotations may be requested, and in many cases received, by telephone, in which cases, a memorandum of the price is made *on the requisition* and afterward transferred to the card form of "request for quotation" for filing. The receipt of quotations may be acknowledged, although this is not invariably done.

Alternatively, of course, all materials used may be classified and a perpetual record kept of prices on each kind of material.

The *purchasing order* is issued when sufficient knowledge as to market prices has been obtained. It (or its copy, rather) then becomes a "live" document, superseding the requisition, which is now filed. It includes a number, a date, and reference to the requisition number on which it is based (for convenience in referring back to the latter). It may contain an acknowledgement stub, to be returned by the firm receiving the order with its acceptance of all of the conditions of the order. This stub will, when received by the purchaser, be attached to his copy of the order. The purchase order states what is wanted, the price and discount, the shipping instructions, the time, place and manner of delivery, and gives any necessary special instructions regarding the billing of the material. A purchase order given verbally, as over the telephone, is of course immediately confirmed in the usual form, marked "confirmation."

These orders are filed in sequence according to the specified dates of delivery of the materials. At some established interval of time prior to such specified date (in the case of important materials) inquiry is made of the shipper regarding delivery probabilities. At any rate, action of this sort is taken as soon as the delivery date is reached.[2] A copy of the purchase order (not necessarily with complete price notations) may go to the stores department for its checking and information. The pur-

[1] Probably everyone is familiar with the type of price cipher commonly used by retail merchants. Take any word or combination of words aggregating ten letters, and let each letter represent a numeral. Thus:

BLACK HORSE
1 2 3 4 5 6 7 8 9 0

On the condition that no letter appears twice, each letter has a definite numerical significance. A notation of a price of $275 would then appear as LOK, and no one unfamiliar with the cipher would grasp its significance.

[2] This illustrates what is commonly referred to as a "follow-up" system.

chase order is a live document until the goods have been received and the invoice therefor approved.

The invoice or bill for the goods, received from the seller, may be drawn off upon the voucher form shown on page 15, or may be stamped for proper entries, which should include a statement of order number (sometimes requisition number also), date of receipt of invoice, approval of quantity, quality and price of goods (date and initials for each approval), name or number of standard account chargeable, and approval for payment. It is not essential that the approval of invoices, other than with respect to price, be committed to the purchasing department. The matter is mentioned here because it suggests itself here.

It is customary for a cash discount to be allowed on many purchases. For this reason, quick action on invoices is necessary, lest the cash discount period may have expired.

If the responsibility for specified delivery of goods rests upon the purchasing department, the program of action in case of deferred deliveries must be carefully worked out here. Close contact with dealers so that accurate information may be at hand as to probable date of deliveries; with operating departments and store-room, so that it may be known how much delay can be tolerated; and with the general market, so that the pros and cons regarding cancellation and replacing of orders can be reviewed in a moment: all these are necessary. The buyer must act quickly, but must never get excited.

In many cases, the operating departments may wish to consider prices in making preliminary estimates for work of production or construction. These prices should be obtained through the purchasing department, and a form of *request for prices* may be employed in large plants for this purpose.

The buyer must thoroughly know the markets which he enters. The trade papers, conference with other buyers, friendly relations with sellers, personal research into the history, conditions and prospects of industries with which he as buyer comes in contact—all of these help. He is a speculator, and he should be at least as well posted on the market for commodities in which he speculates as is the grain operator on weather conditions in the Northwest. If he is far-sighted, he will see many opportunities for advantage by accumulating staple stocks at times of low price. He must then use his expert knowledge to influence the operating or store-room departments to anticipate their requirements.

There is no final criterion by which to gauge the efficiency of purchasing. Prices will vary from uncontrollable factors. In engineering works, it has been found that in a general way prices fluctuate with that of pig-iron. A record of such latter fluctuations may therefore be kept and occasionally compared with variations in average price of commodities consumed. In other industries, some alternative standard staple might be considered as a basis for comparisons.

Inspection

A low range of unit prices, with high rates of consumption, implies that the buyer is disregarding quality in his effort to reduce price. This is a matter for executive control. Important materials (except, unfortunately, coal) are now to a great extent purchased on the basis of specifications of quality prepared by men having the necessary special knowledge. A checking of quality then becomes as definite a matter as a checking of measure or weight. This checking should be performed by trained men and in the laboratory. Shop conditions are too variable, and shop time is too expensive, for quality to be determined, excepting in exceptional cases, by "service tests"—which can scarcely be called tests at all. Any well-managed works will have its testing laboratory and its standard specifications for quality; and the determination of compliance with specifications will rest with the laboratory staff.

Centralized Buying

In organizations of controlling magnitude, a central executive office may include a purchasing department which has staff jurisdiction over all the works. In such cases, the purchasing department will often need to have a local staff in each works, for conducting small, emergency or necessarily local buying. The degree of freedom of action to be allowed these local staffs is a debatable matter, to be determined by such considerations as the size of the works and its location and comparative degree of isolation. This question is largely one of policy. In any case, copies of all purchase orders issued by the local staff should go to the general office.

Purchasing Problems

Ordering Without Prices.—A large buyer who is well posted on the market and of strong personality may place many orders (particularly for unimportant materials) without explicit reference to price. He "does his hammering after the bill comes in," and does it so effectively that his work is often quite as closely conducted as that of the routine man who would not buy a paper of tacks without two or more bids.

Approval of Inferior Goods.—There is always a chance that a dishonest seller and a dishonest employee may get together with a view to passing defective material to the advantage of both and the detriment of the buyer. Systematic detailed records of the findings of inspectors, and subdivision of the work of inspection, have made this chance a rather remote one; and it is seldom that any large loss will be experienced from this cause, because there are too many departments or individuals likely to be affected by the acceptance of bad material.

Graft in the Purchasing Department.—If tales are to be believed, this was once common—almost a part of accepted good practice! Gifts of wines, cigars, and other commodities to favorably influence the buyer toward the seller have for the most part been eliminated because of the spirited contest between these two men brought about by modern competitive conditions. The purchasing agent holds his position because he is a close buyer, and he cannot afford to impair his efficiency for some trifling bribe—to sell his birthright for a mess of pottage.

Improper influences in industrial buying, on a much larger scale, may still exist. When a leading member of the board of directors has commercial relations with a supply business it is often easy for him to exert a tremendous pressure on the purchasing agent who must regard him as one of his superior officials. For example, the director of an automobile manufacturing company may own a works which makes tires. He would of course like to sell his tires to the automobile concern; in many cases he does not hesitate to ask (even in writing) that the purchasing agent "give the business" to his concern. If the director were individually the owner of both the automobile plant and the tire works, there could be no injustice in it; if he is a principal owner, the question is debatable, but it is not usually considered "good business" to interfere in this way. If he is simply one of a large number of stockholders, the procedure is absolutely dishonest. It may be winked at by other directors because they have their own special irons in the fire. The purchasing agent may feel that he cannot question the wishes of a superior. The remedy is in permanent and authoritative organization. If a president is in absolute charge, as he should be, he will not tolerate, and he will protect his subordinates from, such improper influences as have been described.

Speculation.—It would be foolish for a buyer not to profit by anticipation of market fluctuations. His competitors speculate to their advantage, and so must he. But his main business is not speculation, and when he buys largely in anticipation of future requirements he must be ultra-conservative, weighing interest charges against the probability of a rising market, and giving due importance to probable future operating conditions. For him, speculation must be a science; his losses must be exceedingly few and small.

In certain industries—as in the manufacture of linseed oil—the conditions are such that it may be necessary occasionally even to *sell* raw material or *buy* the product. In the particular business mentioned, this is largely due to the comparatively small supply of flaxseed—less than $100,000,000 would usually buy a year's world's crop outright. One effect of such extreme speculation as this is that it naturally engrosses the buyer's entire attention, so that ordinary purchasing and the important problems relating to mill operation should be religiously kept in other hands.

Status.—The purchasing agent was formerly one of the "gilt edged" officials, ranking almost with the elective officers of the directorate and considerably above the works manager. Consideration of his function in the productive machinery suggests that he should rank with the supervisor of plant operation and under the general manager. If an honest administration is expected, he should not be too close to the unpaid and otherwise interested directorate.

Jockeying.—Very few orders are placed at the price quoted by the would-be seller. The Methodist ideal of avoiding "many words in buying and selling" has not yet prevailed, although among the more substantial interests—particularly in engineering lines—it is more common than it was a dozen years ago. The "strictly one-price" plan would be economical in time and trouble.

There are two grounds for dickering as to price. The first is legitimate. It may be that dealers can suggest modifications of specification that will be immaterial to the buyer and which may yet permit of a reduction in price.

The other ground is that of the buyer who tempts or threatens the seller into a concession—pure hoggishness (to use a highly appropriate, if inelegant word). One purchasing agent used to keep careful records of quoted prices and those at which purchases were made. At the close of each day's business he spent a few moments summing up the differences between the two, then announcing the total as what he had "saved the company that day." It is doubtful whether he saved the company much, because sellers soon learn that a certain buyer expects concessions from prices first quoted.

When two or three prices on stated goods have been obtained from different firms, the negotiation for a lowering of price[1] often begins with a lie. Some men are scrupulous about making a direct false statement, but will exert themselves strenuously to produce the desired false impression otherwise. Such men ought not to be buyers. In some cases, however, the dickering is taken up, not with the *lowest* bidder, but, say, with the next to the lowest. He can be told, of course, that he must cut his price if he is to receive the order. If he does cut it, the buyer may then send for the former lowest bidder, who has perhaps now become second lowest; and so the game of see-saw goes on.

In a contracting business, there is a sort of unwritten law that if the contractor uses in preparing a bid a price given him by some material man he should give the order to that man in case he, the contractor, receives the contract. Thus, if Smith, who erects steam piping, gets the lowest prices on gate valves from Brown, and uses that price in making up his bid, then when he gets the job, Brown should get the gate valves. From every standpoint, therefore, close attention is given by contractors to the matter of price on sub-contracts or on material, before the estimate is made; and it is at this period, in such work, that jockeying goes on most actively.

Emergency Purchasing.—Sometimes in case of accident or other sudden emergency, a short cut must be taken, the red tape cut, and a purchase made informally without regard to price.

[1] A delay in acknowledging quotations will often result in a call from the seller which may start this negotiation.

In such cases a special report should be made of the nature of the emergency, the reason why the purchase was necessary, the probable excess cost due to the informality, and the estimated money value of the gain due thereto.

The Place of the Storeroom

Physically, the storehouse is a place where raw or finished materials may be safely kept. The materials include both ordinary standard stock and special supplies, parts or products. They are kept partly in the storeroom proper, and partly in the yard or in branch stockrooms at the different departments; but in theory at least they are all under the control of the stores department.

Nearly every business requires some rudimentary form, at least, of stores department. If for no other reason, there must be a place provided for the keeping of such supplies as may be needed in the repair and maintenance of the plant. Some materials are so costly that they must be specially housed and guarded. If any attempt whatever is made to keep stock costs, the stores department is necessary in order that materials consumed may be properly accounted for. Were there but one productive department, the storeroom organization might possibly be reduced to a simple staff which should merely keep a record of the amount of material on hand, obtaining from this record and the invoices for material purchased a statement of consumption. But when materials go to various departments (and practically speaking, in all cases) the storeroom force is responsible for their care from their entry into the works until they have been charged against specific items or units of product.

The storeroom, thoroughly organized, is concerned with three classes of material: raw supplies, whether standard or special, all of which are first charged to the stores department; work in transit from one department to another in partly finished condition, or parts stored for future assembly; and finished parts awaiting shipment, all of which also pass through the stores department, so that the cycle of production, so far as materials are concerned, begins and ends there.

Storeroom Accounts

Most purchase order requisitions (sometimes all of them) will originate in the storeroom. If these are for unusual or special material, the initial suggestion therefor may come from designing or operating departments. Ordinary stock material will be kept on hand in the required amounts without formal reference to operating departments, small stock being kept in bins, larger materials in floor or yard sections. For each bin or section a perpetual inventory will be kept. Original entries of storeroom accounts may well be made on stock cards, one of which will be provided for each bin or kind of material. On this card, receipts will be debited, deliveries to operating departments will be credited. A pencil "balance" may be noted each time an entry is made. At the top of the card may be a memorandum of the minimum (and possibly the maximum) limit of stock to be kept on hand. When the penciled "balance" figure approaches this minimum, a requisition for new supplies is sent to the purchasing department. Sometimes two minimum quantities are specified: the "ordinary," and the "rush" or "danger" minimum. When the latter is reached, in consequence of delay in placing or filling purchasing orders, or for any other reason, quick action is called for.

These storeroom accounts do not appear on the regular office books of record, excepting that they may give the data for a stock inventory when one is required. They illustrate factory accounting as distinguished from commercial accounting. It may sometimes be desirable that such accounts be kept in terms of *quantity* alone, values being disregarded, and such values being kept in the possession of the office accounting force only.

The function of the storeroom in approving invoices as to date of receipt of goods, and their approval as to quantity and (in a general way) as to quality, has already been suggested. As an alternative and perhaps preferable plan, the stores department may report daily as to goods received, giving description, quantity, condition, quality (?), origin, etc. These reports will give the purchasing department the necessary data for approval of invoices, which then need not leave the business office.

A systematic plan for maintaining suitable stocks not only ensures against waiting for material; it also permits of greatly economizing in carrying charges (interest on money) by avoiding the maintenance of unnecessarily large stocks. When one large corporation was organized, including some ten works none of which had anything like an adequate stores department, a general supervisor of stores was appointed and allowed to organize a storeroom staff. Within one year, the average investment in materials was reduced from $6,000,000 to $1,500,000, representing a saving (with interest at 5 per cent.) of $225,000 per year. This was a saving through *system* alone. No appreciable expenditure for equipment was involved.

Stock Despatching

In the operation of a railroad, one of the most intricate and fascinating parts of the work is the *despatching*, or centralized control of the movement of trains. The train despatcher, by the telegraph and other aids, must put each train in its proper place at the proper time designated by the time-table, or if this in an emergency be impossible, he must temporarily improvise a new time-table which then becomes his ideal until the emergency has passed. The fundamental principle of his work is that no two bodies may occupy the same space at the same time.

In an industrial works, there must be a similar despatching system. It begins with a time-table (usually called a "schedule"), establishing dates for definite steps of progress and for completion and shipment of each piece of work on order. Despatching instructions based on this time-table take the forms of *work orders*, issued to department foremen, and *stock orders*, issued to the storeroom. The order to the foreman gives the number of the production order, the number or designation of the part to be made, the dates of commencement and completion of the proposed work, the operation to be performed, numbers of drawings or specifications to be referred to, the names of the departments from which he is to receive his raw material and to which he is to deliver his finished product, and (where the planning is managed with great detail) the number of the machine on which the work is to be done.

The slip sent to the storeroom will specify the production order number, the material wanted, the department to which it is to be delivered, and the date on which it is to be delivered. A similar slip covering tools to be used may be sent to the toolroom.

For every finished or partly finished piece, some successive department must give its receipt, this receipt becoming then the warrant for a charge against that department. No piece work payment will be made for work not covered by such a receipt.

The office planning department may maintain a schedule or routing board containing a schedule card for each machine in the works (sometimes for each *man* also), so that a glance at a machine card will tell on what order it is working to-day, or will be working ten days hence.

Such a stock despatching system is particularly important in connection with assembly work, where enormous delays and losses are common, though often unsuspected by the authorities. In one machine shop, a force of 13 men was able to assemble 20 machines per month, havig a gross value of $10,000. The introduction of a despatching system is stated to have reduced this force to 6 men, who made a record in the assembling of 100 somewhat smaller machines in one month, the gross value of these being $35,000.

An important individual in the despatching system is the "stock tracer" or "chaser." Besides constantly checking scheduled against actual performance dates, and actively interesting himself in the emergency despatching which is frequently necessary because of unanticipated delays, he investigates those things which workmen (and sometimes foremen) are prone to cover up, such as the reasons for delayed schedules, or the number of pieces or parts spoiled or lost, and the reason therefor. He also keeps posted on the stages of completion of parts in the machines, so that he can tell how much the hands of the clock must be set back, in any department, to make the ideal time-table correspond with actual conditions.

The Stores Department in the Mechanism of Production

In one company, the purchasing and works departments are managed by one vice-president, the correspondence and engineering departments by another. All orders from customers come to the correspondence department, which bases "general orders" thereon. The underlying theory of the organization is that *all shipments are made from stock.* All general orders are consequently sent to the storekeeper. He in turn maintains his stock by issuing a *stock order,* which is really a production order, copies being sent to the engineering, manufacturing and cost-keeping departments. When the general order is received at the storeroom, a notation is made thereon as to assembly materials (*a*) in stock or (*b*) to be made under a stock order. A copy of this notation goes back to the correspondence department.

The engineering department, upon receipt of its copy of a stock order, issues a list of raw material required; copies of which go to the manufacturing, stores and cost departments. Requisitions for this material are made upon the stores department by the foremen of the operating departments concerned. The perpetual inventory of raw materials enables the storeroom to issue purchase requisitions to the buyer when necessary. Copies of these are sent to the receiving clerk (an employee of the stores department) with instructions telling him where to place such new material when received. This clerk reports all receipts.

The engineering department furnishes the manufacturing department, for each shop order, with a list of drawings and specifications applicable, together with a schedule or plan of successive operations under which the work is to be done; this schedule being, however, undated. For new designs, a "stock order" covering the design is issued to the drafting-room, and this work of design is scheduled in precisely the same way as shop work.

The dating of the routing schedule is done by the production clerk of the assembly department, who checks this schedule in its entirety every day. When the work is completed, the manufacturing department delivers its output to the store-house, taking a receipt therefor, and notifying the cost department. A perpetual inventory is maintained of finished parts and products, and abstracts of this are sent weekly to the manufacturing and sales departments.

The system is open to some criticism, particularly because it has been built-up rather than devised as a complete entity. As depicted, it represents the evolution of 15 years, during which the output of the works has increased 1000 per cent.

Economy in Materials

This subject is as broad as the whole field of applied science. It is in this direction that manufacturing is the special work of the chemist and the engineer. A very brief presentation is all that can be offered here.

The essential thing in the utilization of material is to consider *what it is that we utilize.* In coal, it is the heat unit, in the wood which comes to a pulp mill it is (mainly) the fiber, in commercial fertilizers, it is nitrogen, phosphoric acid or potash. It is seldom the case that the material as we buy it is really the thing that we want. What we must do is to determine the thing we want and then to study that thing in all of its associations, transformations and final dispositions, with a relentless scrutiny.

A good illustration of this point would necessitate great familiarity on the part of both writer and reader with some one industry. A fairly satisfactory illustration of what is meant may be obtained from the ten items of coal loss in railroad service as suggested by Mr. Harrington Emerson:

(1) Coal charged by mine, but never placed in car.
(2) Coal shrinkage in transit.
(3) Coal lost in unloading.
(4) Coal shrinkage in storage.
(5) Coal lost in loading locomotive.
(6) Coal wasted in firing up and banking fires.
(7) Coal lost through wasteful firing.
(8) Coal lost through wasteful running.
(9) Coal burned while standing at stations or on side tracks.
(10) Coal lost to ash dump.

Items (7) and (8) are of course capable of great subdivision, and this subdivision should be made. Under item (4), there is a loss both of quantity and of quality. All of the elements of loss should of course be finally computed in heat units.

Good management in the use of materials involves special training in the industry under consideration, or in some industry closely resembling it. It is one of the particular functions of the works supervisor as distinguished from the general manager. There is an art of management, irrespective of application to any particular business. This has been long and generally recognized, men who have shown efficiency in the general administration of one business being often entrusted with the affairs of some distinctly different business in an equally responsible capacity. These men are managers, not oil-mill or paper-mill men. The latter they employ.

That an art of management exists is perhaps the main contention (possibly an undisputed thesis) of this book. Yet it is equally true that experience rules and that in the last analysis the workability of plans must depend upon their approval and execution by the works superintendent, the man who is trained and expert in his particular business. He it is whose enthusiasm and flexibility must not be impaired by half-baked notions originating with the untrained staff of the economist. We must maintain his prestige. He is the most useful man of us all. We must make him more rather than less useful by making his coöperation the matter of first importance at every step. It is he who is the knight of the chessboard.

CHAPTER VI

Burden

In the case of an industry which produces one single invariable staple product—say a city electric railway, which turns out passenger-miles or passenger-trips as its exclusive output—there is perhaps no reason for any separation between direct and indirect expenses. All expenses are divisible by the number of invariable units of product. But such industries are rare, and consequently we must in the great majority of cases separately consider two classes of costs:

(a) Those which are directly chargeable against a specific item of production; labor, materials and direct expense.

(b) Those which are not directly so chargeable.

The latter class may include the roughly classified items.

Factory Expense.

Direct:

Rent.
Light.
Heat.
Power.
Foremen and supervisors.
Non-productive labor.
Repairs and replacements.
Depreciation.
Insurance.
Taxes.

Indirect:

General management.
Office rent, light, heat and power (factory office).
Factory office salaries and supplies.

Selling Expense.

Salesmen's salaries, expenses and commissions.
Freight and drayage on outgoing product.
Rent, light and heat for salesrooms.

Administrative Expense.

Officers' and office salaries, supplies and expenses.

Rent, light and heat for general office.

There is no danger, generally speaking, that the accountants will forget to charge these expenses against production; they appear on invoices exactly like charges for labor or materials. The danger (and the problem to be considered) is one of distribution. In what manner and proportions shall these charges be finally applied against specific production orders? If not properly applied, actual costs and proper selling prices will not be ascertained.

The words *burden, surcharge, expense, indirect expense, general expense,* will be regarded as synonymous for our present purpose, as covering all costs of the nature indicated. The term *fixed expense* is more properly used to describe such unvarying charges as interest on bonds, which go on absolutely regardless of output. This chapter deals with *methods of distributing burden or expense charges.*

Departmental Division

Where a plant is divided into departments in each of which there may be established some satisfactory unit of product, the direct factory expense items may usually be separated so that (as far as this part of the burden is concerned) each department will bear its proper share. The indirect factory, administration and selling expenses may then be distributed in a more or less arbitrary way, on the basis of the value of departmental product, the number of men employed, or by different bases for different items of burden.

As an example, let there be three departments. The first turns out 1000 kegs of nails and employs 100 men. Its costs are, for labor, materials, direct expense and "factory expense (direct)," $1200. In the second department, the figures are 1500 kegs of spikes, 75 men, $2250 cost; and in the third, 500 kegs of staples, 50 men, $600 cost. Let the "indirect factory," "selling" and "administration" expenses aggregate $4500, and let the basis for distribution of these be the number of men employed. The total number of men being 225, the burden per man is $\$4500 \div 225 = \$20$, and the departmental burdens are respectively $2000, $1500 and $1000. The departmental costs corresponding then total $3200 or $3.20 per keg, $3750 or $2.50 per keg and $1600 or $3.20 per keg.

Unit Division

If the total production is 100,000 units, the direct cost $1000 and the indirect cost $500, the total cost is obviously $1500 or 1 1/2 cents per unit. If—as in a linseed-oil mill—there are made various special products in addition to the principal staple, then some of the burden should be placed upon these specialties. An analysis of direct costs might show a cost per gallon for raw oil in tanks of 40 cents, the cost in barrels being 42 1/2 cents. Suppose 500,000 gallons of each to have been produced, and that the whole burden is $5000. It would not be fair to add 1/2 cent per gallon to the cost of each kind of oil to absorb the burden, for the oil in barrels has required not only all of the equipment, indirect labor and supervision of the tank oil: it has in addition required special expenditure of its own in these directions. To some extent, these expenditures may be ascertained; we may compute, for example, the cost of light, heat and power for the cooperage shop; but administrative and selling expenses cannot be ascertained separately, and about the only practicable basis for distribution would be to burden each class of oil in proportion to its aggregate direct cost.

If the burden of $5000 were found to consist of $1000 clearly applicable to barreled oil, with the remaining $4000 undivisible, the total costs would then be computed as follows:

Tank Oil

Direct cost, 40 cents; aggregate cost, $200,000. Since the aggregate cost of the barreled oil is $212,500, tank oil must carry $\frac{200,000}{412,500}$ of the joint burden of $4000, or $1939.39, amounting to $0.003879 per gallon.

The total cost of tank oil per gallon is then 40.3879 cents.

Barreled Oil

Direct cost, 42 1/2 cents; Departmental burden, $1000 or 1/5 cent per gallon; Share of undivisible burden, $4000 − $1939.39 = $2060.61, or $0.00412 per gallon; Total cost per gallon, 43.112 cents.

Division on the Basis of Equivalent Values

Where the factory is neither departmentally organized nor engaged on staple product (this being the usual condition), the problem is quite as unsatisfactory of definite solution, and decidedly more difficult to attack. A plant makes a sewing machine, a bicycle and a plow. The burden is $100. How much of it shall each of the three things stand?

One method of division is to consider the money values of the three things: or, what is easier to determine, the costs for labor, materials and direct expense. Suppose these three charges to have aggregated $15, $22 and $13, respectively: a total of $50. The burden then amounts to $2.00 per $1.00 of direct charge. It would be applied, then, in the proportions, $30 to the sewing machine, making its cost $45; $44 to the bicycle, making its cost $66; and $26 to the plow, making its cost $39; total, $150.

The Direct Labor Basis—Time

A more common system is to apportion burden charges in proportion to the labor time consumed. If this latter were 30 hours for the sewing machine, 50 for the bicycle and 20 for the plow, the $100 of burden would amount to $1.00 per hour, and the burden charge would be distributed to the three products as $30, $50 and $20, making the total costs (with the direct costs already assumed) $45, $72 and $33.

The Direct Labor Basis—Value

Still another way would be to divide the burden on the basis of labor *cost*. Suppose the labor costs to have been, respectively, $6.00, $12.50 and $6.50, totalling $25. The burden is then $4 for each dollar of labor cost, and results in charges of $24, $50 and $26 respectively, making the total costs $39, $72 and $39.

Horse Power and Time Bases

The obvious objections to all of these methods of distribution have suggested others; to which, however, there are objections scarcely less obvious. Many of the factory expense and other charges are related rather to the machinery used than to the men employed. An estimate or measurement of horse-power-hours consumed by the various machines has been proposed as a basis for subdividing surcharge. Another plan is to subdivide on the basis of the time the material is in the works undergoing fabrication. This latter method virtually regards the surcharge as a fixed expense unaffected by shop space conditions. It makes the cheap, bulky product appear relatively less expensive than the small, costly one. The first mentioned plan is too unscientific to be worth the expense and trouble it involves.

Objections to These Systems

Not one of these devices for distributing burden in the case of a diversified output has any relation to the true condition of things. The cost of power is certainly not as a matter of fact in any way related to corresponding labor time or labor cost. The cost of fire insurance is equally without relation to the number of men employed; that of supervision has no necessary association with value or cost of product. Certainly the charge for office salaries does not depend in any way on the power consumption or use of shop time in producing an item of output.

We must then ask, upon what measurable factors, if any, does overhead expense depend? *Not on any one factor.* Heat—to take an example—is in general[1] not necessary for machines, but for men. Expense for heating the factory is incurred because men are there. It is entirely logical, then, to charge cost of heating as a surcharge on labor time. That is, if 100 men work 10 hours during which a heating expense of $12.00 is incurred, we must charge against the production of these men not only the appropriate wage per hour, but 1.2 cents per man per hour over and above this, for factory heat alone.

Discussion of Relationships

Taking up the burden items in the order in which they are given at the beginning of this chapter, we shall find a large proportion of the direct factory expense to be thus related to labor time, or related with equal definiteness to *machine time.* Take the case of power. Men do not consume power,[2] machines

[1] The existence of an automatic sprinkler system in some cases involves expenditure for warming buildings that would not otherwise be heated.

[2] A heating or ventilating fan, or a passenger elevator, might consume power chargeable against labor time.

do. If we know the amount of power (horse-power-hours) consumed by each machine, during a month, and also the total cost of power during that month, we may obtain an hourly rate of charge for power on each machine. In many cases this may be once determined experimentally—or at least the relative proportions of power consumed by the various machines may be so ascertained. As this is a subject of a little complication, we will here consider a rather elaborate illustration.

Suppose the plant to contain three machines, which during a trial month consume 4000, 8000 and 18,000 horse-power-hours respectively. The corresponding numbers of hours run are 400, 200 and 300, so that the horse-power loads on the three machines are 10, 40 and 60. Suppose the output of the power plant during the month to have aggregated 35,000 horse-power-hours. This is somewhat more than the total power consumptions of the three machines; the difference represents power wasted in transmission, or used for running non-productive machines like cranes, etc., and this difference must be of course absorbed in the charges to the productive machines.

Let the cost of power for the month have been $1200. The cost per horse-power-hour *of that portion of power employed in production* was then $1200 ÷ 30,000 = 4 cents. We shall charge the first machine with 4 × 10 = 40 cents, per hour run, or with $160.00 for the month; the second, with $1.60 per hour run or $320.00 for the month; and the third with $2.40 per hour run or $720.00 for the month.

An important point should be mentioned here. We now handle these power charges as direct charges, exactly like labor—charging each job at so much per hour for machine time as well as for man time. Machine time, as we shall find, involves costs additional to that of power. The basis for charges of machine time will be derived from the time cards or piece work slips (see Chapter IV), which will always give the number and time of the machines employed on a given order.

Now in a following month, we may, unless the power loads on the machines are quite variable, *use the hourly power loads already determined* as a basis of subdivision. We need make no further record of power consumption at the individual machines—the only data necessary are the machine times chargeable.

Suppose the power cost in the succeeding month to be $1550; the machine times to be, respectively, 300, 400 and 200. Based on the horse-powers formerly ascertained, the respective power consumptions (horse-power-hours) are $300 \times 10 = 3000$, $400 \times 40 = 16,000$ and $200 \times 60 = 12,000$; making a total of 31,000. The cost per horse-power-hour is now $\$1550 \div 31,000 =$ 5 cents. The machine power rates are:

No. 1, 50 cents per hour,	$150 for the month;
No. 2, $2.00 per hour,	$800 for the month;
No. 3, $3.00 per hour,	$600 for the month.
	$1550

The original measurement of power consumption is easily made, in the case of motor-driven machines, by a recording electrical instrument.

Rent.—This is paid to provide space for both men and machines. In a department which is without (or largely without) machines, it may be charged wholly against labor time. In a department full of machines (like an ordinary machine shop) where a man works as tender to a machine, it should constitute a part of the machine time charge. In other cases a more or less arbitrary division may have to be made, part of the rental cost being distributed in proportion to labor time and part in proportion to machine time.

Light is clearly chargeable against labor time.

Foremen and supervisors are partly in charge of men and partly (the shop engineering and repair force) in charge of machines and buildings. The cost of the first class constitutes a charge against labor time. The repair and maintenance supervision cost is related partly to machine time, and partly to investment in machines and buildings. Probably the best way of handling it is to regard it as a surcharge on distributed repair costs, the basis for division being those costs themselves. Thus, suppose the shop engineer and assistants to receive $1000 per month, and the cost of repairs to have totaled $5000: $1200, $1800 and $2000 for three machines, respectively. We add 1/5 to each of these figures, making them $1440, $2160 and $2400, to absorb the supervision charge.

Repairs and Replacements.—What has just been said will suggest that these expenses should when possible be charged against individual machines. When a non-productive machine is repaired, the cost should be absorbed in the same way as that of power for such a machine, by the charges against *productive* machines. When a *building* is repaired, the cost must be absorbed as a charge like rent, by machines or men or both.

Non-productive Labor.—Such workmen as sweepers, watchmen and to a certain extent general laborers cannot in all cases charge their time to specific production orders. (Power house employees' time is charged against power: repair workmen charge their time to repairs). To some extent these labor costs may be clearly applicable to labor time, as where a gang of men is engaged in bringing parts to an assembly room; or to machine time, as with a crane operator (the *machine* is of course non-productive in this case). Where there is residual doubt as to whether a non-productive labor charge should be placed against labor time or machine time, it must be treated as one of the final indirect expenses, as described below.

Depreciation applies directly against machine time only; indirectly (depreciation of buildings containing no machinery) it may apply against labor time. Further consideration of this important topic will be given in the next chapter.

Insurance is of several kinds: fire, boiler, employees' liability, plate glass, etc. Fire insurance covers buildings, machinery, raw and finished material. If that on buildings is separately kept, it may be treated like rent. Other forms of fire insurance are grouped in the final indirect expenses. Boiler insurance is a cost chargeable against power. Employers' liability insurance is clearly related to labor time.

Taxes are treated like rent.

Final indirect expenses include, besides the few refractory costs already mentioned, all indirect factory, selling and administration charges. They are lumped and distributed as a percentage surcharge on the otherwise prime cost (in some few cases, on the labor cost only).

Recapitulation

The following table then shows what becomes of the listed items of surcharge, and the distribution of elements constituting cost in the light of the present discussion. The list is of course incomplete.[1]

Total cost.
- Direct labor.
  Materials, (a) stock, (b) special. } = Initial prime cost.
- Direct expense.
- Distributed burden: Charged against labor time.
  - Wasted time.
  - Taxes (part).
  - Heat.
  - Depreciation (part).
  - Light.
  - Foremen and supervisors.
  - Employers' liability insurance.
  - Rent (part), fire insurance on buildings (part).
  - Non-productive labor (part).
- Distributed burden: Charged against machine time (productive machines only).
  - Power, boiler insurance.
  - Repairs and replacements.
  - Repair supervision.
  - Depreciation (part).
  - Rent, taxes (part of each).
  - Non-productive labor (part).
  - Fire insurance on buildings (part).

  (Initial prime cost together with the burdens charged against labor time and machine time) } Corrected prime cost.
- Distributed burden: Charged against corrected prime cost (or labor cost).
  - Fire insurance, excepting on buildings.
  - Non-productive labor (part).
  - Factory indirect expenses.
  - Selling expense.
  - Administrative expense.
  - Spoiled work.
  - Standard patterns, tools, jigs and templates.
  - Designing and development expense.

[1] The following is the list or standard classification of factory burden expenses adopted by one large corporation:

Maintenance of Property Expenses.—Main buildings; other structures; drainage and sewer pipes; tracks, trestles and turntables; roadways and grounds; permanent shop fixtures; warming and ventilating system; engines and pumps; accumulators and gas producers; boilers; electric plant; electric motors; oil, heating and melting furnaces; gas, heating and melting furnaces; coal, heating and melting furnaces; steam, gas and water pipes; pneumatic pipes and fittings; hydraulic pipes and fittings; cranes and conveying machinery; fixed machine tools; foundations and installation of tools; shafting, hangers and pulleys; belting, renewals; belting, supplies; belting, labor; portable power tools; portable tools, durable; portable tools, non-durable; formers and cast iron dies; cast steel dies; metal flasks; rolling stock; fire protective equipment; miscellaneous property.

Other Indirect Factory Expenses.—Foremen and assistants; power, heat and light: fuel, handling, purchased, supplies, engineers and firemen; other engineers and firemen; water supply; inspectors; watchmen; oil; waste; car rental and detention; testing material; shipments of patterns; wooden flasks and templates; cartage expenses; stable expenses; defective shop work; defective work corrected outside; defective purchased material; drawing room errors; changes conceded to purchasers; loss on obsolete material; shop supplies; shop expenses; unloading incoming material; other handling of material; storeroom attendants; toolroom attendants; oilers; unclassified labor; superintendence; special mechanical experts; shop engineering; traveling engineers; production department, clerical; standardizing engineering; charts and diagrams, clerical expense; accounting, clerical expense; storekeeping, clerical expense; purchasing, clerical expense; other office clerks and attendants; other shop clerks; drawing room expenses; hastening incoming material; telegraph expenses; telephone expenses; plant traveling expenses; stationery and printing; repairs of plant office furniture and appliances; injuries to persons; legal expenses; donations and gratuities; taxes; insurance on property; other plant office supplies; other plant expenses.

An examination of this table will show that there may be some justification for charging a customer 60 to 80 cents per hour for the time of a workman to whom we actually pay in wages only 30 or 40 cents. If we remember that interest charges have not been included here (the percentage of profit may be regarded as a substitute for interest) we may also understand why machine time charges of 50 cents and upward per hour are not uncommon.

Objections to the Definite System

This method of distributing surcharge is as definite, logical and complete as any system could be. The objection to it is on the ground of its complication. As a matter of fact, it is complicated to devise and first apply, but simple in its continued application after having once been inaugurated. If it is worth while to study costs at all, it is worth while to pursue the study until our knowledge is accurate. It may easily take two or three years to get a system like this in working order; it may need frequent modification and revision. Hard and fast rules cannot be laid down; and in all cases some simplification is permissible.

CHAPTER VII

Depreciation

There is one item of surcharge for which no invoice is received: an element of cost which may be forgotten, or at least inadequately estimated. Fortunately, however, when this cost—depreciation—is ascertained, there is never any question as to its distribution. It applies to specific pieces of material equipment. If these are productive machines, depreciation is a part of the machine time rate. If they are non-productive machines, buildings or structures, depreciation may be distributed in the same way as rent.

Depreciation is a charge against production intended to offset the progressive decrease in value of equipment which experience shows to be universal. Suppose a plant to be built for a million dollars; and to run ten years, paying its owners $60,000 each year, accumulating no surplus or reserve funds. It is then put on the market for sale; but the highest price that can be obtained for it is $250,000. The owners *thought* they had *made* $600,000; what they had *really lost* was $150,000. They were paying the cost of depreciation out of their resources instead of out of their profits. Depreciation is unavoidable; it is a part of the cost of operation; our only option is to pay it out of resources or out of profits. The latter is the only safe plan.[1]

[1] In this respect, the interests of the bond holders of a manufacturing concern may differ from those of the stockholders. The latter may be regarded as partners in the business enterprise; the former virtually (often actually) hold a mortgage on the physical property. The stockholder wants his dividends; he may wish to sell out at any time, and few things keep up the price of stock like a steady dividend record. The bondholder cares comparatively little about dividends, or even about profits in excess of bond interest requirements. He is more interested in seeing the value of the plant maintained so that if he should ever have to foreclose his mortgage he may be able to realize on it. The stockholder may try to ignore depreciation and to declare dividends not really earned; the bondholder prefers to see earnings "put back into the property." The latter would pay for depreciation out of profits; the former might seek to pay for it out of resources. Large investors feel that their bond holdings are safest only when they have adequate stock holdings in the same enterprises. Many conflicts in management have arisen from the diverse interests of bond and stock owners. It must be remembered that ownership of a bond gives its holder no voice in the control of a business. The trust deed under which bonds are issued may, however, impose certain restrictions on the management.

Reasons for Depreciation

For a novice, it is not easy to understand why a machine or structure "kept in good repair" should depreciate. A new machine is installed. Expenditure for repairs, slight at first, after a time rapidly increases; it may then become more or less steady for a long term of years, the machine meanwhile regularly operating. At some time or times in the history of the machine a costly change or replacement of parts may be necessary, a virtual rebuilding perhaps, and finally, in every case, like the "one hoss shay" the machine becomes no longer a synthetic structure. No replacement of parts short of an entire reconstruction—the building of a new machine—can maintain it as a productive entity. It has reached the "final renewal" stage, and is itself scrap, as far as its present owners are concerned.

There are three causes of depreciation:

(a) The action of time and the elements;

(b) Necessary or unnnecessary wear in service;

(c) The introduction of improved equipment which makes present equipment obsolete for purposes of competition.

This last factor is the most difficult of prediction. A machine may last a long time—perhaps a thousand years; but *ultimately* these three causes will operate to destroy it.

Systems of Depreciation

Since no invoice is ever received to remind us of this expense, it is particularly necessary that we adopt a system, as nearly as possible automatic in its operation, whereby attention may be called to the matter and the proper charges made.

To some moderate extent, expenditures for repairs offset depreciation; and if, as is universal practice, current repairs are charged against cost of operation, a part of the depreciation cost will be taken care of in this way. "Deferred repairs" or replacements—large expenditures for maintaining the condition or operating efficiency of the plant—are sometimes so costly that the manager hesitates to charge them immediately against operation; they may result in a "bad showing" for the month during which they are charged. It is therefore sometimes the practice to distribute the charge over a series of months, depending on the anticipated life of the replacement or the duration of the economy due thereto. For example, suppose during 6 months of the year the profits have aggregated $50,000. In July, there is an apparent profit of $8000, but during this month an old steam engine is replaced by a new one, costing $12,000. If this $12,000 were at once charged against operation, the month of July would show a loss of $4000. The manager may, consequently, order the distribution of the $12,000 charge over the balance of the year—$2000 each month. The July profits will then appear as $6000. This is a quite common practice, although not one to be regarded as conservative.

In this illustration, we have not regarded the new steam engine as adding to the value of the plant, since it takes the place of another engine which goes to the junk pile. It has not increased the potential output of the works one iota, and cannot therefore be regarded as an "improvement," which might be associated with an increase in capitalization and not charged against cost of operation. Nor have we regarded the case as one of the replacement of a properly depreciated machine for the replacement of which we have funds on hand, set aside out of the earnings of past years in anticipation of this very emergency.

Final renewals eventually become necessary because of depreciation. Four methods may be suggested for paying for them: First, we may wait until they do become necessary and then pay for them either out of the current month's profits or by distributing the cost over several future months, borrowing from our surplus, as in the case of the steam engine, just cited. Either method involves the borrowing of money or the retention of an adequate surplus in the treasury. With these disadvantages, this method of caring for final renewals is not uncommon. The vital objection is that eventually there comes a time when renewals become excessively frequent and costly. The industry will then be wrecked unless its resources or surplus are very large; and if they do happen to be very large, it is probably because this condition of things has been anticipated, the surplus having been accumulated as a depreciation reserve; for which very reserve, scientifically adjusted and accumulated, the advocates of another method presently to be described contend.

A second common method is this: No great surplus is accumulated, and no systematic effort is made to forcast depreciation; but liberal expenditures are constantly made for the extension, enlargement and improvement of plant, these betterments being paid for, not by increasing capitalization, but out of earnings. If in the example of the million-dollar plant referred to the $600,000 profits had been distributed *after* the expenditure of $850,000 for betterments, possibly the value of the plant after its 10 years of operation might have been still a million dollars. Its apparent profits would then have been real profits.

This system reminds one of a man who refuses to give his wife a regular allowance, but occasionally when in good humor hands her a check or orders flowers and candy sent to the house. There is nothing scientific about it. It may be safe, if the improvement expenditures are liberal and judicious; but to determine as to their liberality and judiciousness involves the same knowledge of the facts of depreciation that is needed for a far more logical system.

A third method employed (whether avowedly or not) by some large corporations is as follows: The management and the insiders generally wish to retain their positions. This is easy, providing the stockholders in general are kept satisfied by the regular payment of dividends and accumulation of surplus. Every effort is therefore made to keep the dividend rate constant. Each year, a reserve for depreciation is set aside; and the amount of reserve is that amount which the year's business "will stand." If earnings have been low, little or no addition will be made to the reserve.

If earnings have been high, the reserve fund will be heavily augmented. The plan has some attractive aspects: it seems to care for the income of the "widow and orphan" stockholders as a prime consideration. But in reality it cares for their income at the hazard of their capital. It puts first what should come second; and is unsafe excepting for very prosperous corporations in industries having no protracted periods of depression.

What may be called the definitive method of depreciating is not at all common: less common, no doubt, in this country than in England, where the accountancy of depreciation is carefully studied and practised.

In this method, the cost of depreciation is an annual charge against earnings, fixed by estimating the probable life of each unit of material equipment. *The sum of money thus charged off and laid aside as a depreciation reserve is that sum which, invested at compound interest, will accumulate in such amounts as will suffice to replace the units of equipment as their lives expire.*

Depreciation Rates

The basis of the depreciation rate is the number of years of anticipated life. The simplest plan is to consider that the loss in value will be the same each year throughout the life; so that a 20 years' life to total worthlessness would involve (ignoring interest) a charge of 5 per cent. on the initial cost of the machine each year. What is sometimes referred to as "5 per cent. depreciation" may have a different meaning, as follows:

Initial value, $1.00; depreciation first year, 5 per cent. of $1.00 = 5 cents, leaving residual value 95 cents; depreciation second year, 5 per cent. of 95 cents = 4 3/4 cents, leaving residual value 90 1/4 cents; and so on.

It is seldom the case that the equipment is without value at the end of its productive life. It may be sold, as second hand machinery or material, or as scrap. In a few instances, however, the residual value is *negative.* A marine boiler, for example, at the end of its life, might be worth less than the cost of removing it from the hull of the vessel; so that the junk man would have to be paid for taking it away. The "initial cost" to be considered as a basis for depreciation will in such case exceed the sum of money actually paid for the boiler in the first place. In ordinary cases, the annual charge will be *less* than the quotient of initial cost by years of life. If the life is 20 years and the residual or scrap value 10 per cent. of the initial cost, the proportion of the initial cost to be annually charged against earnings for depreciation will be $(100-10) \div 20 = 4\ 1/2$ per cent. (interest being ignored).

In the case of an industry using leased premises, where all material equipment reverts to the owner at the expiration of the lease, the maximum life of any unit cannot exceed the prospective duration of the lease, and there is no residual value.

The estimate of probable life of various kinds of machinery and structures is a matter for the expert. Various tables and opinion have been published.

An English authority gives the following figures:

Electric generators, 30 years life to 8 per cent. residual value.
Electric motors, 25 years life to 9 per cent. residual value.
Armored cables, 35 years life to 15 per cent. residual value.
Storage batteries, 15 years life to 0 per cent. residual value.
Arc lamps, 12 years life to 0 per cent. residual value.
Lamp posts, 40 years life to 0 per cent. residual value.

Electrical instruments, 12 years life to 0 per cent. residual value.

Water tube boilers, 25 years life to 5 per cent. residual value.

Steam engines, 25 years life to 6 per cent. residual value.

The reports of 13 large street railway companies in 1909 showed the whole depreciation charge to have varied from 0.7 to 13.7 per cent. of gross earnings.

The possibility of early obsolescence through the introduction of improved machinery must be carefully considered in fixing probable life. New and unfamiliar machinery is usually heavily depreciated because it is felt that important improvements are likely to be made at an early date. Probably the safest estimates on life duration are those made on live stock—horses, for example. Small portable tools are depreciated heavily. Depreciation rates in general are higher than they formerly were.

The estimates of probable life may be (probably should be) revised every year. Thus, if on the basis of 20 years life of a machine initially costing $100 we are charging off $5 each year (scrap value and interest are here ignored), and if after 10 years we find that the machine is likely to wear out or become obsolete in 2 years more, we charge off $25 instead of $5 during each of those remaining two years. On the other hand, if the life promises to exceed the original estimate, we will decrease the charge. It is quite possible that after the expiration of the predicted life term a machine may go on operating for some years, with no depreciation charge against it. The machine is carried on the books as scrap; interest earned by its proportion of the depreciation reserve fund will be "velvet."

The Depreciation Fund

Having determined the probable loss of value in the term of years representing the anticipated life of the machine, we must now ascertain what sum of money must be set aside annually in order that it may eventually equal the sum representing the loss of value.

This depends upon the rate of interest and the frequency of compounding. Tables are available for the purpose, but the following formula makes a table unnecessary.

$$S = A\frac{r^n - 1}{r - 1};$$

where A is the annual appropriation, in dollars, n is the number of years of life (compounding assumed to be annual), r is 1 plus the fraction indicated by the probable rate of interest; *i.e.*, if the interest rate is 4 per cent., r = 1.04; and S is the loss in value in dollars to be offset by the annual appropriation A. Thus, a machine costing \$100, with a residual value of \$10, would give S = \$90. If the life is 10 years, and interest costs 4 per cent., r = 1.04 and

$$A = S\,\frac{r-1}{r^n-1}$$

$$= 90.\ \frac{0.04}{1.04^{10}-1} = 90.\ \frac{0.04}{0.4802} = \$7.49\tfrac{1}{2};$$[1]

whereas if the reserve fund had not been compounded, the annual charge would have been \$9.00.

The determination of the rate of interest to be assumed in this computation is a problem for the banker. No small degree of judgment is involved in fixing upon a rate which shall be fair and yet conservative over a period of years to come. It is of course possible to revise the rate from time to time, just as estimated life rates may be revised. In the example with which we are dealing, suppose it to be concluded, after 5 years, that a rate of 5 per cent. instead of four may hereafter be safely assumed. The present accumulated reserve for depreciation is first ascertained. This is to go on accumulating interest for 5 years more at 5 per cent.; let the amount which will be thus realized be called x. Then the amount to be realized by further annual appropriations is 90 − x, and

$$A = (90 - x)\ \frac{0.05}{1.05^5 - 1},$$

from which A, the revised annual appropriation necessary, may be computed. It will of course be somewhat less than \$7.49 1/2.

Betterments

While this is a satisfactory system from an accounting standpoint, though somewhat complicated in application, it is not yet complete from the manager's point of view. A vital question with him is the distribution of the depreciation reserve. It is intended to be used, when the machines wear out, for their re-

[1] To evaluate an expression like 1.04^{10}, we must employ a table of logarithms. To multiply two numbers, we add their logarithms; the sum is the logarithm of the product. To raise a number to any power, we multiply the logarithm of the number by the exponent; the product is the logarithm of the required quantity. Thus:

$\log 1.04 = 0.017033$

$(\log 1.04) \times 10 = 0.17033 = \log (1.4802 = 1.04^{10})$.

placement; and unless so used it is idle money: the plant will gradually become less productive on account of the presence of worn-out equipment.

ANNUITY TABLE[1]

Giving yearly payments in dollars required to redeem $100 at end of any year from 1 to 100. Interest compounded annually.

Life, years	Rate of interest							Life, years
	2½%	3%	3½%	4%	4½%	5%	6%	
1	100.00	100.00	100.00	100.00	100.00	100.00	100.00	1
2	49.38	49.26	49.14	49.02	48.90	48.78	48.54	2
3	32.51	32.36	32.19	32.03	31.88	31.72	31.41	3
4	24.08	23.90	23.73	23.55	23.37	23.20	22.86	4
5	19.02	18.84	18.65	18.46	18.28	18.10	17.74	5
6	15.65	15.46	15.27	15.08	14.89	14.70	14.34	6
7	13.25	13.05	12.85	12.66	12.47	12.28	11.91	7
8	11.45	11.25	11.05	10.85	10.66	10.47	10.10	8
9	10.05	9.84	9.64	9.45	9.26	9.07	8.70	9
10	8.93	8.72	8.52	8.33	8.14	7.95	7.59	10
11	8.01	7.81	7.61	7.42	7.23	7.04	6.68	11
12	7.25	7.05	6.85	6.66	6.47	6.28	5.93	12
13	6.60	6.40	6.21	6.01	5.83	5.65	5.30	13
14	6.05	5.85	5.66	5.47	5.28	5.10	4.76	14
15	5.58	5.38	5.18	4.99	4.81	4.63	4.30	15
16	5.16	4.96	4.77	4.58	4.40	4.23	3.90	16
17	4.79	4.60	4.40	4.22	4.04	3.87	3.54	17
18	4.47	4.27	4.08	3.90	3.72	3.55	3.24	18
19	4.18	3.98	3.79	3.61	3.44	3.27	2.96	19
20	3.91	3.72	3.54	3.36	3.19	3.02	2.72	20
21	3.68	3.49	3.30	3.13	2.96	2.80	2.50	21
22	3.46	3.27	3.09	2.92	2.75	2.60	2.30	22
23	3.27	3.08	2.90	2.73	2.57	2.41	2.13	23
24	3.09	2.90	2.73	2.56	2.40	2.25	1.97	24
25	2.93	2.74	2.57	2.40	2.24	2.10	1.82	25
26	2.78	2.59	2.42	2.26	2.10	1.96	1.69	26
27	2.64	2.46	2.29	2.12	1.97	1.83	1.57	27
28	2.51	2.33	2.16	2.00	1.85	1.71	1.46	28
29	2.39	2.21	2.04	1.89	1.74	1.60	1.36	29
30	2.28	2.10	1.94	1.78	1.64	1.51	1.26	30
31	2.17	2.00	1.84	1.69	1.54	1.41	1.18	31
32	2.08	1.90	1.74	1.60	1.46	1.33	1.10	32
33	1.99	1.82	1.66	1.51	1.37	1.25	1.03	33
34	1.90	1.73	1.58	1.43	1.30	1.18	0.96	34
35	1.82	1.65	1.50	1.36	1.23	1.11	.90	35

[1] Reproduced by permission from *Lecture Notes on Business Features of Engineering Practice* (Second Edition, Revised) by President A. C. Humphreys.

ANNUITY TABLE.—*Continued.*

Life, years	Rate of interest						Life, years
	2½%	3%	3½%	4%	4½%	5%	6%	
36	1.75	1.58	1.43	1.29	1.16	1.04	.84	36
37	1.67	1.51	1.36	1.22	1.10	0.98	.79	37
38	1.61	1.45	1.30	1.16	1.04	.93	.74	38
39	1.54	1.38	1.24	1.11	0.99	.88	.69	39
40	1.48	1.33	1.18	1.05	.93	.83	.65	40
41	1.43	1.27	1.13	1.00	.89	.78	.61	41
42	1.37	1.22	1.08	0.95	.84	.74	.57	42
43	1.32	1.17	1.03	.91	.80	.70	.53	43
44	1.27	1.12	0.99	.87	.76	.66	.50	44
45	1.23	1.08	.95	.83	.72	.63	.47	45
46	1.18	1.04	.91	.79	.68	.59	.44	46
47	1.14	1.00	.87	.75	.65	.56	.41	47
48	1.10	0.96	.83	.72	.62	.53	.39	48
49	1.06	.92	.80	.69	.59	.50	.37	49
50	1.03	.89	.76	.66	.56	.48	.34	50
51	.99	.85	.73	.63	.53	.45	.32	51
52	.96	.82	.70	.60	.51	.43	.30	52
53	.93	.79	.67	.57	.48	.41	.29	53
54	.89	.76	.65	.55	.46	.39	.27	54
55	.87	.73	.62	.52	.44	.37	.25	55
56	.84	.71	.60	.50	.42	.35	.24	56
57	.81	.68	.57	.48	.40	.33	.22	57
58	.78	.66	.55	.46	.38	.31	.21	58
59	.76	.64	.53	.44	.36	.30	.20	59
60	.74	.61	.51	.42	.35	.28	.19	60
61	.71	.59	.49	.40	.33	.27	.18	61
62	.69	.57	.47	.39	.31	.26	.17	62
63	.67	.55	.45	.37	.30	.24	.16	63
64	.65	.53	.44	.35	.29	.23	.15	64
65	.63	.51	.42	.34	.27	.22	.14	65
66	.61	.50	.40	.32	.26	.21	.13	66
67	.59	.48	.39	.31	.25	.20	.12	67
68	.57	.46	.37	.30	.24	.19	.12	68
69	.56	.45	.36	.29	.23	.18	.11	69
70	.54	.43	.35	.27	.22	.17	.10	70
71	.52	.42	.33	.26	.21	.16	.10	71
72	.51	.41	.32	.25	.20	.15	.09	72
73	.49	.39	.31	.24	.19	.15	.09	73
74	.48	.38	.30	.23	.18	.14	.08	74
75	.47	.37	.29	.22	.17	.13	.08	75
76	.45	.35	.28	.21	.16	.13	.07	76
77	.44	.34	.27	.21	.16	.12	.07	77
78	.43	.33	.26	.20	.15	.11	.06	78
79	.41	.32	.25	.19	.14	.11	.06	79
80	.40	.31	.24	.18	.14	.10	.06	80

ANNUITY TABLE.—*Continued.*

Life, years	Rate of interest							Life, years
	2½%	3%	3½%	4%	4½%	5%	6%	
81	.39	.30	.23	.17	.13	.10	.05	81
82	.38	.29	.22	.17	.13	.09	.05	82
83	.37	.28	.21	.16	.12	.09	.05	83
84	.36	.27	.21	.15	.11	.08	.05	84
85	.35	.26	.20	.15	.11	.08	.04	85
86	.34	.26	.19	.14	.10	.08	.04	86
87	.33	.25	.18	.14	.10	.07	.04	87
88	.32	.24	.18	.13	.10	.07	.04	88
89	.31	.23	.17	.13	.09	.07	.03	89
90	.30	.23	.17	.12	.09	.06	.03	90
91	.30	.22	.16	.12	.08	.06	.03	91
92	.29	.21	.15	.11	.08	.06	.03	92
93	.28	.21	.15	.11	.08	.05	.03	93
94	.27	.20	.14	.10	.07	.05	.03	94
95	.26	.19	.14	.10	.07	.05	.02	95
96	.26	.19	.13	.09	.07	.05	.02	96
97	.25	.18	.13	.09	.06	.04	.02	97
98	.24	.18	.12	.09	.06	.04	.02	98
99	.24	.17	.12	.08	.06	.04	.02	99
100	.23	.16	.12	.08	.06	.04	.02	100

Explanation of Tables

The *Annuity table* shows what sum of money must be invested each year in order that the accumulations, at a stated rate of interest, compounding being annual, may amount to $100 at the expiration of any number of years from 1 to 100. Thus, for this case considered on page 96, we wish to know the annual investment at 4 per cent. necessary to realize $90 at the end of 10 years. The table shows that at 4 per cent., $8.33 would redeem $100 in ten years; consequently, to realize $90 we should have to set aside, as computed in the text, $\$7.49\frac{1}{2} = \$8.33 \times \frac{90}{100}$.

The *compound interest table* may be used to determine the amount of accumulations of such depreciation fund at any given time. Thus, in the instance discussed, $1 invested at 4 per cent. would in 5 years become $1.2167. Proceeding, we write

$1 invested 5 years at 4 per cent. =	$1.2167
$1 invested 4 years at 4 per cent. =	1.1699
$1 invested 3 years at 4 per cent. =	1.1249
$1 invested 2 years at 4 per cent. =	1.0816
$1 invested 1 year at 4 per cent. =	1.0400
Total accumulations from $1 annually, in 5 years =	$5.6331

The accumulations from an investment of $7.49½ annually will then be $\$7.49\frac{1}{2} \times 5.6331 = \$42.20$. Consider now the problem suggested at the

Explanation of Tables—*Continued*

bottom of page 96. The table shows that \$1 in 5 years at 5 per cent. will realize \$1.2763. Our accumulation of \$42.20 will then realize \$42.20 × 1.2763 = \$53.87. (This is the amount called x in the formula.) We have now to realize \$90.00 – \$53.87 = \$36.13, in the next five years, at 5 per cent. The annuity table shows that to realize \$100 we should have to set aside \$18.10 annually. We shall actually have to set aside \$18.10 × 0.3613 = \$6.54, which should be equal to the value of A obtained in solving the formula at the bottom of page 88.

COMPOUND INTEREST TABLE[1]

Giving Value of $1 at End of Any Year from 1 to 100, at Various Interest Rates. Interest Compounded Annually

Years	½%	1%	1½%	2%	2½%	3%	3½%	4%	4½%	5%	5½%	6%	6½%	7%	Years
1	1.0050	1.0100	1.0150	1.0200	1.0250	1.0300	1.0350	1.0400	1.0450	1.0500	1.0550	1.0600	1.0650	1.0700	1
2	1.0100	1.0201	1.0302	1.0404	1.0506	1.0609	1.0712	1.0816	1.0920	1.1025	1.1130	1.1236	1.1342	1.1449	2
3	1.0151	1.0303	1.0457	1.0612	1.0769	1.0927	1.1087	1.1249	1.1412	1.1576	1.1742	1.1910	1.2079	1.2250	3
4	1.0202	1.0406	1.0614	1.0824	1.1038	1.1255	1.1475	1.1699	1.1925	1.2155	1.2388	1.2625	1.2865	1.3108	4
5	1.0253	1.0510	1.0773	1.1041	1.1314	1.1593	1.1877	1.2167	1.2462	1.2763	1.3070	1.3382	1.3701	1.4026	5
6	1.0304	1.0615	1.0934	1.1262	1.1597	1.1941	1.2293	1.2653	1.3023	1.3401	1.3788	1.4185	1.4591	1.5007	6
7	1.0355	1.0721	1.1098	1.1487	1.1887	1.2299	1.2723	1.3159	1.3609	1.4071	1.4547	1.5036	1.5540	1.6058	7
8	1.0407	1.0829	1.1265	1.1717	1.2184	1.2668	1.3168	1.3686	1.4221	1.4775	1.5347	1.5938	1.6550	1.7182	8
9	1.0459	1.0937	1.1434	1.1951	1.2489	1.3048	1.3629	1.4233	1.4861	1.5513	1.6191	1.6895	1.7626	1.8385	9
10	1.0511	1.1046	1.1605	1.2190	1.2801	1.3439	1.4106	1.4802	1.5530	1.6289	1.7081	1.7908	1.8771	1.9672	10
11	1.0564	1.1157	1.1779	1.2434	1.3121	1.3842	1.4600	1.5395	1.6229	1.7103	1.8021	1.8983	1.9992	2.1049	11
12	1.0617	1.1268	1.1956	1.2682	1.3449	1.4258	1.5111	1.6010	1.6959	1.7959	1.9012	2.0122	2.1291	2.2522	12
13	1.0670	1.1381	1.2136	1.2936	1.3785	1.4685	1.5640	1.6651	1.7722	1.8856	2.0058	2.1329	2.2675	2.4098	13
14	1.0723	1.1495	1.2318	1.3195	1.4130	1.5126	1.6187	1.7317	1.8519	1.9799	2.1161	2.2609	2.4149	2.5785	14
15	1.0777	1.1610	1.2502	1.3459	1.4483	1.5580	1.6753	1.8009	1.9353	2.0789	2.2325	2.3966	2.5718	2.7590	15
16	1.0831	1.1726	1.2690	1.3728	1.4845	1.6047	1.7340	1.8730	2.0224	2.1829	2.3553	2.5404	2.7390	2.9522	16
17	1.0885	1.1843	1.2880	1.4002	1.5216	1.6528	1.7947	1.9479	2.1134	2.2920	2.4848	2.6928	2.9170	3.1588	17
18	1.0939	1.1961	1.3073	1.4282	1.5597	1.7024	1.8575	2.0258	2.2085	2.4066	2.6215	2.8543	3.1067	3.3799	18
19	1.0994	1.2081	1.3270	1.4568	1.5987	1.7535	1.9225	2.1068	2.3079	2.5270	2.7656	3.0256	3.3086	3.6165	19
20	1.1049	1.2202	1.3469	1.4859	1.6386	1.8061	1.9898	2.1911	2.4117	2.6533	2.9178	3.2071	3.5236	3.8697	20
21	1.1104	1.2324	1.3671	1.5157	1.6796	1.8603	2.0594	2.2788	2.5202	2.7860	3.0782	3.3996	3.7527	4.1406	21
22	1.1160	1.2447	1.3876	1.5460	1.7216	1.9161	2.1315	2.3699	2.6337	2.9253	3.2475	3.6035	3.9966	4.4304	22
23	1.1216	1.2572	1.4084	1.5769	1.7646	1.9736	2.2061	2.4647	2.7522	3.0715	3.4262	3.8197	4.2564	4.7405	23
24	1.1272	1.2697	1.4295	1.6084	1.8087	2.0328	2.2833	2.5633	2.8760	3.2251	3.6146	4.0489	4.5331	5.0724	24
25	1.1328	1.2824	1.4509	1.6406	1.8539	2.0938	2.3632	2.6658	3.0054	3.3864	3.8134	4.2919	4.8277	5.4274	25

[1] Reproduced by permission from *Lecture Notes on Business Features of Engineering Practice* (Second Edition, Revised) by President A. C. Humphreys.

COMPOUND INTEREST TABLE—*Continued*

Giving Value of $1 at End of Any Year from 1 to 100, at Various Interest Rates. Interest Compounded Annually

Years	½%	1%	1½%	2%	2½%	3%	3½%	4%	4½%	5%	5½%	6%	6½%	7%	Years
26	1.1385	1.2953	1.4727	1.6734	1.9003	2.1566	2.4460	2.7725	3.1407	3.5557	4.0231	4.5494	5.1415	5.8074	26
27	1.1442	1.3082	1.4948	1.7069	1.9478	2.2213	2.5316	2.8834	3.2820	3.7335	4.2444	4.8223	5.4757	6.2139	27
28	1.1499	1.3213	1.5172	1.7410	1.9965	2.2879	2.6202	2.9987	3.4297	3.9201	4.4778	5.1117	5.8316	6.6488	28
29	1.1556	1.3345	1.5400	1.7758	2.0464	2.3566	2.7119	3.1187	3.5840	4.1161	4.7241	5.4184	6.2107	7.1143	29
30	1.1614	1.3478	1.5631	1.8114	2.0976	2.4273	2.8068	3.2434	3.7453	4.3219	4.9840	5.7435	6.6144	7.6123	30
31	1.1672	1.3613	1.5865	1.8476	2.1500	2.5001	2.9050	3.3731	3.9139	4.5380	5.2581	6.0881	7.0443	8.1451	31
32	1.1730	1.3749	1.6103	1.8845	2.2038	2.5751	3.0067	3.5081	4.0900	4.7649	5.5473	6.4534	7.5022	8.7153	32
33	1.1789	1.3887	1.6345	1.9222	2.2589	2.6523	3.1119	3.6484	4.2740	5.0032	5.8524	6.8406	7.9898	9.3253	33
34	1.1848	1.4026	1.6590	1.9607	2.3153	2.7319	3.2209	3.7943	4.4664	5.2533	6.1742	7.2510	8.5092	9.9781	34
35	1.1907	1.4166	1.6839	1.9999	2.3732	2.8139	3.3336	3.9461	4.6673	5.5160	6.5138	7.6861	9.0623	10.6766	35
36	1.1967	1.4308	1.7091	2.0399	2.4325	2.8983	3.4503	4.1039	4.8774	5.7918	6.8721	8.1473	9.6513	11.4239	36
37	1.2027	1.4451	1.7348	2.0807	2.4933	2.9852	3.5710	4.2681	5.0969	6.0814	7.2501	8.6361	10.2786	12.2236	37
38	1.2087	1.4595	1.7608	2.1223	2.5557	3.0748	3.6960	4.4388	5.3262	6.3855	7.6488	9.1543	10.9467	13.0793	38
39	1.2147	1.4741	1.7872	2.1647	2.6196	3.1670	3.8254	4.6164	5.5659	6.7048	8.0695	9.7035	11.6583	13.9948	39
40	1.2208	1.4889	1.8140	2.2080	2.6851	3.2620	3.9593	4.8010	5.8164	7.0400	8.5133	10.2857	12.4161	14.9745	40
41	1.2269	1.5038	1.8412	2.2522	2.7522	3.3599	4.0978	4.9931	6.0781	7.3920	8.9815	10.9029	13.2231	16.0227	41
42	1.2330	1.5188	1.8688	2.2972	2.8210	3.4607	4.2413	5.1928	6.3516	7.7616	9.4755	11.5570	14.0826	17.1443	42
43	1.2392	1.5340	1.8969	2.3432	2.8915	3.5645	4.3897	5.4005	6.6374	8.1497	9.9967	12.2505	14.9980	18.3444	43
44	1.2454	1.5493	1.9253	2.3901	2.9638	3.6715	4.5433	5.6165	6.9361	8.5572	10.5465	12.9855	15.9729	19.6285	44
45	1.2516	1.5648	1.9542	2.4379	3.0379	3.7816	4.7024	5.8412	7.2482	8.9850	11.1266	13.7646	17.0111	21.0025	45
46	1.2579	1.5805	1.9835	2.4866	3.1139	3.8950	4.8669	6.0748	7.5744	9.4343	11.7385	14.5905	18.1168	22.4726	46
47	1.2642	1.5963	2.0133	2.5363	3.1917	4.0119	5.0373	6.3178	7.9153	9.9060	12.3841	15.4659	19.2944	24.0457	47
48	1.2705	1.6122	2.0435	2.5871	3.2715	4.1323	5.2136	6.5705	8.2715	10.4013	13.0653	16.3939	20.5485	25.7289	48
49	1.2768	1.6283	2.0741	2.6388	3.3533	4.2562	5.3961	6.8333	8.6437	10.9213	13.7838	17.3775	21.8842	27.5299	49
50	1.2832	1.6446	2.1052	2.6916	3.4371	4.3839	5.5849	7.1067	9.0326	11.4674	14.5420	18.4202	23.3067	29.4570	50

COMPOUND INTEREST TABLE—*Continued*

Giving Value of $1 at End of Any Year from 1 to 100, at Various Interest Rates. Interest Compounded Annually

Years	½%	1%	1½%	2%	2½%	3%	3½%	4%	4½%	5%	5½%	6%	6½%	7%	Years
51	1.2896	1.6611	2.1368	2.7454	3.5230	4.5154	5.7804	7.3910	9.4391	12.0408	15.3418	19.5254	24.8216	31.5190	51
52	1.2961	1.6777	2.1689	2.8003	3.6111	4.6509	5.9827	7.6866	9.8639	12.6428	16.1856	20.6969	26.4350	33.7253	52
53	1.3026	1.6945	2.2014	2.8563	3.7014	4.7904	6.1921	7.9941	10.3077	13.2749	17.0758	21.9387	28.1533	36.0861	53
54	1.3091	1.7114	2.2344	2.9135	3.7939	4.9341	6.4088	8.3138	10.7716	13.9387	18.0149	23.2550	29.9833	38.6122	54
55	1.3156	1.7285	2.2679	2.9717	3.8888	5.0821	6.6331	8.6464	11.2563	14.6356	19.0058	24.6503	31.9322	41.3150	55
56	1.3222	1.7458	2.3020	3.0312	3.9860	5.2346	6.8653	8.9922	11.7628	15.3674	20.0511	26.1293	34.0078	44.2071	56
57	1.3288	1.7633	2.3365	3.0918	4.0856	5.3917	7.1056	9.3519	12.2922	16.1358	21.1539	27.6971	36.2183	47.3015	57
58	1.3355	1.7809	2.3715	3.1536	4.1878	5.5534	7.3543	9.7260	12.8453	16.9426	22.3174	29.3589	38.5725	50.6127	58
59	1.3421	1.7987	2.4071	3.2167	4.2925	5.7200	7.6117	10.1150	13.4234	17.7897	23.5448	31.1205	41.0797	54.1555	59
60	1.3489	1.8167	2.4432	3.2810	4.3998	5.8916	7.8781	10.5196	14.0274	18.6792	24.8398	32.9877	43.7498	57.9464	60
61	1.3556	1.8349	2.4799	3.3467	4.5098	6.0684	8.1538	10.9404	14.6586	19.6131	26.2060	34.9670	46.5936	62.0027	61
62	1.3624	1.8532	2.5171	3.4136	4.6225	6.2504	8.4392	11.3780	15.3183	20.5938	27.6473	37.0650	49.6222	66.3429	62
63	1.3692	1.8717	2.5548	3.4819	4.7381	6.4379	8.7346	11.8332	16.0076	21.6235	29.1679	39.2889	52.8476	70.9869	63
64	1.3760	1.8905	2.5931	3.5515	4.8565	6.6311	9.0403	12.3065	16.7279	22.7047	30.7721	41.6462	56.2827	75.9559	64
65	1.3829	1.9094	2.6320	3.6225	4.9780	6.8300	9.3567	12.7987	17.4807	23.8399	32.4646	44.1450	59.9411	81.2729	65
66	1.3898	1.9285	2.6715	3.6950	5.1024	7.0349	9.6842	13.3107	18.2673	25.0319	34.2501	46.7937	63.8372	86.9620	66
67	1.3968	1.9477	2.7116	3.7689	5.2300	7.2459	10.0231	13.8431	19.0894	26.2835	36.1339	49.6013	67.9867	93.0493	67
68	1.4038	1.9672	2.7523	3.8443	5.3607	7.4633	10.3739	14.3968	19.9484	27.5977	38.1213	52.5774	72.4058	99.5627	68
69	1.4108	1.9869	2.7936	3.9211	5.4947	7.6872	10.7370	14.9727	20.8461	28.9775	40.2179	55.7320	77.1122	106.5321	69
70	1.4178	2.0068	2.8355	3.9996	5.6321	7.9178	11.1128	15.5716	21.7841	30.4264	42.4299	59.0759	82.1245	113.9894	70
71	1.4249	2.0268	2.8780	4.0795	5.7729	8.1554	11.5018	16.1945	22.7644	31.9477	44.7636	62.6205	87.4626	121.9686	71
72	1.4320	2.0471	2.9212	4.1611	5.9172	8.4000	11.9043	16.8423	23.7888	33.5451	47.2256	66.3777	93.1476	130.5065	72
73	1.4392	2.0676	2.9650	4.2444	6.0652	8.6520	12.3210	17.5160	24.8593	35.2224	49.8230	70.3604	99.2022	139.6419	73
74	1.4464	2.0882	3.0094	4.3293	6.2168	8.9116	12.7522	18.2166	25.9780	36.9835	52.5632	74.5820	105.6504	149.4168	74
75	1.4536	2.1091	3.0546	4.4158	6.3722	9.1789	13.1986	18.9453	27.1470	38.8327	55.4542	79.0569	112.5176	159.8760	75

COMPOUND INTEREST TABLE—*Continued*

Giving Value of $1 at End of Any Year from 1 to 100, at Various Interest Rates. Interest Compounded Annually

Years	½%	1%	1½%	2%	2½%	3%	3½%	4%	4½%	5%	5½%	6%	6½%	7%	Years
76	1.4609	2.1302	3.1004	4.5042	6.5315	9.4543	13.6605	19.7031	28.3686	40.7743	58.5042	83.8003	119.8313	171.0673	76
77	1.4682	2.1515	3.1469	4.5942	6.6948	9.7379	14.1386	20.4912	29.6452	42.8130	61.7219	88.8284	127.6203	183.0421	77
78	1.4755	2.1730	3.1941	4.6861	6.8622	10.0301	14.6335	21.3108	30.9792	44.9537	65.1166	94.1581	135.9156	195.8550	78
79	1.4829	2.1948	3.2420	4.7798	7.0337	10.3310	15.1456	22.1633	32.3733	47.2014	68.6980	99.8075	144.7501	209.5648	79
80	1.4903	2.2167	3.2907	4.8754	7.2096	10.6409	15.6757	23.0498	33.8301	49.5614	72.4764	105.7960	154.1589	224.2344	80
81	1.4978	2.2389	3.3400	4.9729	7.3898	10.9601	16.2244	23.9718	35.3525	52.0395	76.4626	112.1438	164.1792	239.9308	81
82	1.5053	2.2613	3.3901	5.0724	7.5746	11.2889	16.7922	24.9307	36.9433	54.6415	80.6681	118.8724	174.8509	256.7260	82
83	1.5128	2.2839	3.4410	5.1739	7.7639	11.6276	17.3800	25.9279	38.6058	57.3736	85.1048	126.0047	186.2162	274.6968	83
84	1.5204	2.3067	3.4926	5.2773	7.9580	11.9764	17.9883	26.9650	40.3430	60.2422	89.7856	133.5650	198.3202	293.9255	84
85	1.5280	2.3298	3.5450	5.3829	8.1570	12.3357	18.6179	28.0436	42.1585	63.2544	94.7238	141.5789	211.2111	314.5003	85
86	1.5356	2.3531	3.5982	5.4905	8.3609	12.7058	19.2695	29.1653	44.0556	66.4171	99.9336	150.0736	224.9398	336.5154	86
87	1.5433	2.3766	3.6521	5.6003	8.5699	13.0870	19.9439	30.3320	46.0381	69.7379	105.4299	159.0781	239.5609	360.0714	87
88	1.5510	2.4004	3.7069	5.7124	8.7842	13.4796	20.6420	31.5452	48.1098	73.2248	111.2286	168.6227	255.1323	385.2764	88
89	1.5588	2.4244	3.7625	5.8266	9.0038	13.8839	21.3644	32.8071	50.2747	76.8861	117.3462	178.7401	271.7159	412.2458	89
90	1.5666	2.4486	3.8189	5.9431	9.2289	14.3005	22.1122	34.1193	52.5371	80.7304	123.8002	189.4645	289.3775	441.1030	90
91	1.5744	2.4731	3.8762	6.0620	9.4596	14.7295	22.8861	35.4841	54.9013	84.7669	130.6092	200.8324	308.1870	471.9802	91
92	1.5823	2.4979	3.9344	6.1832	9.6961	15.1714	23.6871	36.9035	57.3718	89.0052	137.7927	212.8823	328.2191	505.0188	92
93	1.5902	2.5228	3.9934	6.3069	9.9385	15.6265	24.5162	38.3796	59.9536	93.4555	145.3713	225.6553	349.5534	540.3701	93
94	1.5981	2.5481	4.0533	6.4330	10.1869	16.0953	25.3742	39.9148	62.6515	98.1283	153.3667	239.1946	372.2744	578.1960	94
95	1.6061	2.5735	4.1141	6.5617	10.4416	16.5782	26.2623	41.5114	65.4708	103.0347	161.8019	253.5463	396.4722	618.6697	95
96	1.6141	2.5993	4.1758	6.6929	10.7026	17.0755	27.1815	43.1718	68.4170	108.1864	170.7010	268.7590	422.2429	661.9766	96
97	1.6222	2.6253	4.2384	6.8268	10.9702	17.5878	28.1329	44.8987	71.4957	113.5957	180.0896	284.8846	449.6887	708.3150	97
98	1.6303	2.6515	4.3020	6.9633	11.2445	18.1154	29.1175	46.6947	74.7130	119.2755	189.9945	301.9776	478.9184	757.8970	98
99	1.6385	2.6780	4.3665	7.1026	11.5256	18.6589	30.1366	48.5625	78.0751	125.2393	200.4442	320.0963	510.0481	810.9498	99
100	1.6467	2.7048	4.4320	7.2446	11.8137	19.2186	31.1914	50.5049	81.5885	131.5013	211.4686	339.3021	543.2013	867.7163	100

In general, when a machine is replaced, the effort will be made not only to fill its place, but to put in something better—more substantial or economical. This "something better" may cost more than the loss of value of the machine; so that the depreciation reserve fund may be insufficient to pay for the new machine. No matter, it was not the object of this fund to pay for betterments, but merely to insure the maintenance of the plant at its original value. If betterments are contemplated, they may profitably be paid for by increasing capitalization, for they increase the worth of the plant. But *only the increased expenditure* should be regarded as a basis for new capitalization. If the depreciation accumulations are $90 and the scrap value $10, while the replacement machine costs $200, just half of this latter sum will be paid for out of the depreciation reserve and the scrap sale proceeds; only the balance of $100 will be covered by increase of capitalization.

In many cases of minor betterment, no formal "increase of capitalization" is made. The procedure is merely (for example) to take the needed $100 from the cash surplus on hand, accounting for it hereafter by adding $100 to the estimated physical value of the plant, which has been enlarged to this extent. The betterment expenditure of $100 has thus been charged to capital instead of to earnings.

Obviously, there is a broad opportunity here for evidence of a disposition varying anywhere from the safely conservative to that of a gambler. In general, no charges will be made to capital unless the "betterment" is one which actually increases output or decreases cost. Even this last condition is not deemed sufficient by the most conservative managers.

A corporation may occasionally seek to conceal its profits by excessive provision for depreciation, the funds thus created being put back into the plant in the form of replacements and extensive betterments. Where there is no "graft" in contracts or orders for betterments, this practice is of course financially sound, although stockholders might prefer a fuller distribution of earnings. But from the standpoint of the consuming public it is beginning to be felt that earnings should not be hidden in this way: that after a fair provision for depreciation has been made, and a reasonable profit paid to the owners of the business, any further surplus should be wiped out by a reduction in price to the consumer.

The following table (from *Industrial Progress*) gives a few examples of betterments paid for out of earnings:

RETURN INTO PROPERTY FROM INCOME

Company	Kind of service	Year ending	Per cent. of gross earnings put back into property as betterments
United States Census, 1907.	939 electric railway companies including small amount of electric light.	Dec. 31, 1907..	17.1
United States Census, 1902.	799 companies, all electric railways, including some electric light.	Dec. 31, 1902..	17.4
State of N. Y.—District No. 1.	Electric railways..........	June 30, 1907.	11.7
State of N. Y.—District No. 2.	Electric railways..........	June 30, 1907..	19.9
State of Massachusetts.....	Electric railways...........	Sept. 30, 1908.	15.3
United Rys. and Elec. Co., Baltimore.	Urban and suburban railway.	Dec. 31, 1908..	21.7
Brooklyn Rapid Transit Co.	Surface and elevated railway.	June 30, 1909..	19.3
International Tract. Co., Buffalo.	Urban, suburban and interurban railway.	Dec. 31, 1908..	19.3
Twin City Rapid Transit Co.	Urban and suburban railway.	Dec. 31, 1908..	18.1
Kansas City Ry. and Lt. Co.	Railway and electric light..	May 31, 1908...	17.8
Boston Elevated Railway...	Surface, elevated, subway railway.	Sept. 30, 1909.	18.6
American Cities Ry. and Lt. Co.	5 electric railway and light companies, Birmingham, Memphis, Little Rock, Knoxville and Houston.	Dec. 31, 1908..	14.9
Capital Tract. Co., Washington.	Urban and suburban railway.	Dec. 31, 1908..	14.1
Philadelphia Rapid Transit Co.	Surface, elevated, subway railway.	June 30, 1909..	9.7
Great Britain and Ireland..	Municipal and company railways.	Dec. 31, 1907..	28.7
Great Britian and Ireland..	Municipal railways........	Mar. 31, 1908..	31.2
Great Britain and Ireland..	Company railways.........	Dec. 31, 1907..	22.2
Glasgow Corporation Tramways.	Municipal railways........	May 31, 1909...	42.6

Depreciation Accounting

The simple statement of entries to be made on books of record here given will perhaps be more intelligible to some readers after examination of the chapter on principles of accounting. In order to complete the present discussion, however, we cite the following rules:

At the end of each year, set aside the necessary reserve fund as computed by debiting *Loss and Gain* and crediting *Depreciation Reserve.* This sum of money then disappears as a gain and appears as a liability. When a machine is replaced, pay for the replacement, crediting *Cash* and debiting *Depreciation Reserve.*[1]

This latter account is sometimes alternatively entitled *Final Renewal Fund.* Depreciation is thus treated as an accruing liability, like royalties, insurance, taxes, etc. An artificial account is created to which we assumedly *owe* certain money held in the cash drawer or banks. When the money is spent, we wipe out our debt to this artificial account. Whenever interest is declared on money credited to Final Renewal Fund, we credit such interest also to that fund, debiting cash.

[1]The distribution of depreciation charges against specific production orders may be effected in the manner described in the preceding chapter.

CHAPTER VIII

Industrial Organization

The function of management, somewhat narrowly and briefly stated, is to control and reduce costs. This is the ideal in view in any discussion of types, forms and functions of industrial organization. The whole of this book is devoted to a presentation of the conditions of productive efficiency. There are, however, three important duties in management which may well be emphasized here. They are:

1. To produce a development of the plant that will augment its importance in the field it serves.
2. To conserve the physical value of the works in all of its parts.
3. To protect the industry, as far as may be, from sudden and heavy losses.

The Plant Must Grow

An industry is a living thing, and no living thing is in truly healthful condition excepting as it grows, changes. The manufacturing plant is seldom, and should be never, in settled condition for perfectly standardized operation. If it is not enlarging, either as a whole or in certain departments, it will be increasing its output by minor improvements in equipment; or at least will by such methods be reducing its cost of operation.

The study of industrial investment is then one which the manager must not outgrow. His first care will be that no expenditures are charged to plant improvement which ought to be charged as repairs against earnings, lest his costs look well now at the certainty of a serious burden in the future. His expenditures for proposed betterments will be rigorously scrutinized and recorded and the results weighed. In advance of every such expenditure, inquiry will be made as to its amount, the exact benefit to be expected and the time when that benefit will be realized, and the probable indirect effects of such expenditure on every part of the business. After the improvement has been made the final results will be compared with those anticipated.

Managers—particularly managers who are engineers—are fond of spending money on equipment which they think will, after due allowance for interest and depreciation, reduce costs of operation. It is a difficult thing to say what amount of net saving must be realized to make the proposed expenditure attractive. In pure theory, any net saving whatever after all deductions have been paid would seem to warrant a betterment; but estimates are so uncertain, conditions so variable, proposed costs of equipment are so often exceeded and anticipated savings therefrom so frequently not realized, that some rather large estimated percentage of net saving is usually considered essential. Many works managers regard 15 to 20 per cent. as not unreasonably high. Some ask 25 to 35 per cent. Improvements (and industrial investments generally) must pay better in the United States than in most manufacturing countries, because interest rates are higher here.

There are two classes of betterment: those intended to increase output, either by the direct addition of machinery or by its better arrangement and alignment; and those which have in view a reduction in cost of operation. The latter result is usually secured as a by-product of improvements of the first class; and such improvements are, consequently, those to which the most attention should be devoted.

When it is finally agreed that this or that betterment will produce some stated saving, it is obvious that every day's failure to realize such saving means a loss of potential profit. Therefore, improvements are often installed with such haste that they may later have to be virtually duplicated; or at least so that they may require extensive changes and repairs to fit them for satisfactory operation. We must not be in too much of a hurry to realize prospective savings. On the other hand, it may be unprofitable to resort to excessive solidity of construction which shall either seriously delay the realization of the anticipated economy, or impair the future flexibility of the plant. The ideal of a "mill without a repair account" is not necessarily good. English railways were originally constructed much more substantially, and at a much greater cost per mile, than American railways. Operating expenses on the former consumed 60 per cent. of the gross receipts; on the latter, 90 per cent. But whereas the better

American roads have in the last decade been virtually reconstructed with increased clearances and weight limits, the cost of doing this on the English roads, on account of their heavy masonry structures, would be prohibitive. The latter roads cannot therefore be made suitable for the heavier equipment which modern conditions invite.

A large mill was kept down in output to half capacity because of a four hour overload condition in its power plant. The suggestion was made that a 250 horse-power steam engine be installed to overcome this condition; and inquiry was made for an engine of a highly economical type, on which 4 months was asked for delivery. The engine finally purchased was somewhat less economical, but it was obtained from stock and was running within 16 days from the day of decision. The saving in value of mill time was estimated to be such that it would offset the difference in fuel consumption of the two engines for 23 years, a period longer than the conservatively estimated life of either machine.

When a "run down" concern is taken in hand for rehabilitation, those improvements first made should be, generally, the ones which will effect the greatest savings. Encouragement is thus given those who are supplying the money. Naturally, however, considerations of cost reduction may have to give way to those of safety or surety of operation. It is necessary to "keep things running" whether we reduce costs or not.

An improvement looking toward cost economy, to be attractive, must produce a return at least equal to the profits made on the business as a whole. If it will not do this, the money might better be spent in simply enlarging the business. The exception should be made, however, that in a business subject to great fluctuations, cost reducing improvements might be preferable to extensions because they place the industry in a more strategic competitive position. No one wishes to derive his whole income from low-yielding government bonds; but a few such bonds mixed with a variety of securities makes the whole mass regarded as better collateral.

Two points should be especially watched in connection with improvement expenditures: preliminary estimates should cover the *entire* cost of the improvement and related undertakings; and costs should be totaled frequently during construction so that early warning may be had in case they are exceeding estimates.

The Manager as a Watchdog

The manager virtually holds the property in trust for its owners. He must be ready to turn it over to them, at any moment and without notice, in as good condition as when he received it. The importance of providing for depreciation out of earnings has been mentioned; and this is one of the principal guarantees that a conservative manager gives.

Besides machinery, structures and equipment, the physical property entrusted includes the stocks of raw and finished materials and of by-products and scrap. These must be inventoried, not at their cost (which would seem to be the obvious way) but at their estimated market value, or (to be conservative) at some percentage less than that market value. If raw material were carried on the books at cost, and the price of such material gradually fell, there might be an ultimate large difference between book value and actual value. When the plant runs (in a dull season) at a low output, the unit costs of products are high—admissibly so, because it is usually better to run at a loss than not to run. But these products cannot be sold at such high cost; they must be sold, when sold, at the market price, and they should be carried on the books, therefore, at market price rather than cost price. This is the only safe way.

Not merely the good condition of equipment as for exhibition purposes, but its conservative and effective use are parts of the watch dog function. The manager must determine (as far as it is in the province of any individual to determine) whether the plant shall run 10 hours or 24 hours daily—if the former, whether the tours shall be 8-hour or 12-hour; whether it shall run the year round or shall, because of bad business conditions, lack of storage capacities or other reasons, have its seasonal shut-downs and consequent periods of disorganization. Twenty-four hour service reduces fixed cost (interest, taxes, insurance, general administration, etc.) per unit of product; but it is not economical in labor or material because night work is for human beings necessarily less efficient than day work. The 24-hour mill will be the one in which fixed charges are important items in the total cost, in which continuous service is necessary to the consumer or in which wastes of material occur when operation ceases. The 8-hour day as compared with the 12-hour day is apt to lead to a higher cost of labor to the employer and a lower day's wages to the workman. If coupled with the introduction of a modern system of labor payment, the change from a 12-hour to an 8-hour day may easily be made without injury to either. Twelve hours is too long a regular day's work for any man.

Some industries are fortunate in producing staple commodities of such small bulk that several months' output may be stored in times of business depression. Such storage represents cost in interest charges; but the cost may be small in comparison with either of the two which the industry must face which—because its product is variable or because it cannot be stored—has to close its doors in dull times. Tremendous expenses go on, necessarily, whether the doors are open or closed. Other expenses, like those for material, are practically eliminated; but the *cost of the organization* of employees and their directors must either be nearly eliminated at great hardship to the men and hampering to the future of the mill, or else carried on with no production against which to apply it. This is a dilemma indeed. The decision must be made with reference to many factors: the probable duration of the shut down; the inducements offered the men elsewhere; the degree of skill and training required of the men; the possibility of utilizing them on such works of repair and construction as the manager may have courage to undertake, etc.

No expense is so easily reduced by the management as that for repairs and maintenance. In "hard times," or when attacked by the public, it is easy for the railways, for example, to produce immediate large savings in "maintenance of way" and "maintenance of equipment" expenditures. But these are frequently in truth not savings at all. The expenditures have been merely deferred. Their very postponement will be sure ultimately to increase them. A manager may refuse to make needed repairs in order that the cost statements may look well, but the day of reckoning will come.

Insurance

When the manager has done his best to enlarge and conserve the property, he must still guard against its crippling or destruction by those fortuitous acts which he can neither foresee nor prevent. What he cannot guard against, he will insure against; paying some one, better able to bear the loss, to stand the risk of loss. Certain possible losses of this kind he cannot insure against. A stupid or malicious employee may produce damage that is uninsurable; but in few cases can such loss be overwhelming. Damage by fire, water, cyclone, or boiler explosion, to materials coming or going by land or water; against such he may if he will obtain guarantees more or less comprehensive. It is equally important for him to protect his owners, as far as may be, against losses by claims for damages on account of personal injuries sustained by employees or by the public through the acts of employees. He will coöperate with indemnity companies by strict adherence to their rules provided for action in case of such accident,[1] just as he may coöperate with the fire

[1] A prompt report of any accident, accompanied with names and addresses of witnesses, is always required. The law may prescribe the filing of reports with some state official. A written statement may be secured from a person injured, as to the cause of the accident and the nature of the injury. Any tools or parts of machines which have figured in an accident may be marked and preserved for identification. Photographs showing the surrounding conditions may be useful.

Personal injuries to employees may be settled by (a) re-employment after recovery; (b) payment of money; (c) guarantee of continuous re-employment in spite of disability.

In all such cases, a full release from liability is usually demanded from the injured person. Facilities for affording "first aid" and for conveying men to hospitals must be regarded.

The subject of workmen's compensation (for industrial accidents) is receiving no less attention than the equally important subject of prevention of such accidents by proper safeguards. The American Museum of Safety Devices maintains in the Engineering Societies Building, 29 West 39th Street, New York, a permanent exhibit of safety appliances of all sorts. Reference should be made to the paper by John Calder, " The Mechanical Engineer and the Prevention of Accidents," in the *Transactions* of the American Society of Mechanical Engineers.

The law has been seriously unjust to the workman in the matter of compensation for personal injuries. He has borne too large a share of the losses arising from accidents. This has been due in large measure to the old common-law "fellow servant" doctrine, under which—briefly speaking—a workman is deprived of adequate redress for injuries sustained by reason of the contributory neglect of a fellow employee.

The present program of the reformers is, full liability for damages where the employer is morally wrong; no liability where the moral wrong is on the part of the workman. In those cases where there has been "fellow servant" negligence, or where there is a necessary risk associated with the trade, graded liability for compensation is proposed. As the employer must pay for the depreciation of his plant, so also must he pay for the depreciation of his men; but in order to more fully distribute losses of the third and least avoidable class it is proposed that fixed payments be made by the state for each standard injury, the necessary funds being provided by a tax upon industrial concerns.

Workmen's compensation laws embodying these or similar provisions have been passed in Ohio, New Jersey, Kansas, Massachusetts, Wisconsin and New York. In the first three states, the laws have not yet (September, 1911) gone into effect. In Massachusetts, the statute has been declared constitutional. It provides for voluntary submission to the statutory scale by any workman who so elects: the indemnities are then paid automatically without the necessity for an action at law. The "fellow servant" doctrine is abrogated by a provision of the statute, which thus makes it the employer's interest to voluntarily accede to the new scale. In Ohio, the workman pays 10 per cent. of the cost of indemnification. In New York, the law has been declared unconstitutional by the Court of Appeals. The Wisconsin law, like that of Massachusetts, provides for arbitration at the options of employer and employee. It abrogates wholly the "assumption of risk" defence and partly, the "fellow servant" defence. These defences are based on court decisions rather than on constitutional provision. The Wisconsin statute, unlike that of Massachusetts, leaves insurance companies (to his manifest advantage in the matter of rates) by installing automatic sprinklers.

Large concerns with separated plants may "carry their own insurance." The works will not all burn at once; a total loss at one of them might not be crippling, so that the very size of the organization enables it to distribute its own losses without recourse to insurance. A carefully estimated fund should in such cases be set aside in anticipation of losses. As this fund will grow, withdrawals may occasionally be made unless the plant also grows.

The modern theory of insurance is that the owner shall in all cases bear a part of the risk. This is accomplished by not insuring at full value. *Stock* insurance companies are ordinary business corporations—in the *mutual* companies the insured plants are part owners. They participate therefore in profits or losses. Many of the mutual companies limit their operations to certain classes of plant, and lay great stress on their physical condition with respect to fire prevention. Their rates may in such cases be lower than those of the stock companies, but the cost of complying with the requirements which may be set by their various inspectors is sometimes a serious matter.[1]

the "contributory negligence" defence unimpaired. It has been upheld by the Supreme Court of the State.

Some nineteen state legislatures are now considering the question of industrial insurance. Efforts are being made to secure the passage of a federal law by Congress. Compensation laws should of course be uniform in all the states. Opposition to the proposed enactments has come not from the employers—the plans are in fact a protection to the smaller industries—but from the indemnity companies, which regard then as bringing the states into competition with themselves. The progress of workmen's insurance and compensation systems in Europe is summarized in the 24th (1909) Annual Report of the United States Commissioner of Labor (Washington, 1911).

Fire Losses in the United States

[1] In the year 1907, the average fire loss per capita was in this country $2.51, the corresponding average in six European countries being 33 cents, while even in Russia it was only $1.16 (Bulletin 418, United States Geological Survey, 1910). During the same year, 1449 persons were killed and 5654 injured by fires in the United States. The annual loss by fire has steadily increased from about $70,000,000 in 1875–'80 to from $150,000,000 to $200,000,000 at present; the last figure representing a waste of about $23,000 *per hour*, days, nights and Sundays included. The payment of insurance does not wipe out the loss; it merely distributes it; and not much more than half the total direct losses are covered by insurance. No insurance protects against loss of profits. We pay for maintenance of fire departments in our large cities, each year, $1.53 per capita; the corresponding average cost in ten European cities of about the same size is only 20 cents. Our immense investments in water works, it is estimated, represent a total capitalization such that the 22 per cent. attributable to fire protection amounts to $157,000,000. The total cost of fires, including direct losses, insurance premiums, water works, fire departments and private fire protection, but not including losses of wages and profits following destruction of plant, aggregates $450,000,000 annually.

The reason is primarily the use of timber for construction. From Europe the almost

The General Forms of Industrial Ownership

A business may be conducted by:

1. An individual.[1]
2. A partnership.
3. A corporation.

invariable report is "no wooden buildings in the city." Two-thirds of our 1907 loss was on frame buildings. In our treeless states, the loss per capita was $2.30; in states endowed with an abundance of timber it was $2.89.

The direct losses in the San Francisco fire of 1906, exclusive of earthquake damage, probably aggregated $300,000,000. The city had been built with narrow streets lined by high buildings nearly all of wood or of wooden frames. These were badly congested and exposed, with excessive wall and floor openings and for the most part of very light flimsy construction. There was a notable absence of sprinklers or other protective devices; the public water distribution system was defective; and the topography and meteorological conditions of the city were such as to increase fire hazard. A special commission of insurance experts reported just six months before the fire that San Francisco "had violated all underwriting traditions and precedents by not burning up." In fact, its whole history had been one of numerous fires and heavy fire losses. When the final conflagration came, an official report concluded that "no other result . . could . . have been expected." (United States Geological Survey, Bulletin 324.)

Nothing is as insidious as fire hazard. An electric cable in a lead sheath seems safe; but an insect has appeared which gnaws through these sheaths. An electric flat iron caused a loss of $1,250,000.

The campaign against fire loss includes agencies both public and private. In the former class belong municipal fire services by steamer ("fire engine"), fire boat, high-pressure water supplies and all the equipment and organization of a paid and thoroughly trained corps of men. In the latter are comprised:

1. The automatic sprinkler system with two sources of water supply. 2. Watchman's or thermostatic alarm systems. 3. Inside protection by pails, small hose, extinguishers, etc. 4. Outside protection by private hydrant system and private drilled fire brigade. 5. Protection against exposure.

Insurance Rates.—The rate of insurance is expressed in cents of annual premium paid per $100 of insured valuation. Rates in each district are fixed by a local rating board, for each risk, according to its resemblance to or departure from a certain standard of hazard contemplated in establishing the "base rate" for the district. It often pays to modify plans for building construction to meet the views of the rating boards as to wall thicknesses, heights of parapets, etc., particularly in cities; and even more serious questions may have to be considered in determining as to a proper course between high insurance cost (or refusal to insure) on the one hand and undesirable construction expense or limitation of operating conditions on the other. Monitors, for example, expose adjacent roof areas, and metal sash and frames may be required therein. Every opening in a floor or wall may be penalized. Automatic fire doors on the latter may reduce the penalty, but an opening bricked up means insurance money saved. There is a penalty for a bare ceiling which may be partially avoided by the use of fire-resisting plaster. The mere absence of whitewash from an exposed ceiling may make a difference of 5 or 6 cents in the rate.

For each risk, the rating board prepares a schedule about like the following (extreme example).

1. Base rate	$0.30
2. Excessive area $0.02, walls deficient $0.06, joists and posts insufficient, $0.04	0.12
3. Monitor in roof $0.10, roof plank and floors below standard $0.07	0.17
4. Floor openings $0.02, elevator $0.02, stairway $0.02	0.06
5. Partitions $0.05, steam pipes exposed $0.50	0.55
6. Occupancy $2.00, shavings vault $0.50, blower $0.25, ceilings $0.06	2.81

[1] Many very large enterprises are conducted by individuals. Sometimes, in these cases, the business is called a "company" or "works," with or without inclusion of the name of the individual owner. In such instances, the responsibility of the individual owner must be properly declared before some public officer.

To a corporation of controlling magnitude we give the meaningless name, a "trust."

Partnership

A *partnership* is the simplest form of joint ownership. There may be any number of owners from two upward. A *general* partner is liable for the firm's debts, without limit; a *special* partner is liable only to the extent of his contribution to the capital. Each partner contributes something to the partner-

7. Boiler house openings $0.10, doors on same not standard $0.38............	0.48
8. Absence of small protective equipment..................................	0.80
(Clarence K. Mowry in *The Factory*, August, 1910.) Total,............	5.29

In this case, items 2, 3, and 4 could scarcely be remedied without radical reconstruction of the plant. The following work was done: a partition covered with tin (5 cents, item 5); the basement cleared out (50 cents reduction, "occupancy," item 6); the shavings vault ventilated by a flue and its exhaust blower repaired (75 cents, item 6); ceilings whitewashed (6 cents, item 6); boiler house openings provided with fire doors (38 cents, item 7); and some barrels, hose and pails were purchased (80 cents, item 8). The entire cost involved was about $500, and the annual rate was reduced $2.54 thereby. It might have paid to rearrange the steam piping (item 5).

Where the hazard is classed as "ordinary," the following clause is often used in insurance policies covering buildings and contents:

"In consideration of the rate at which this policy is written, it is expressly stipulated that this [insurance] company shall be liable for no greater proportion of any loss than the amount hereby insured bears to .... per cent. of the actual cash value of the property...... nor for more than the proportion which this policy bears to the total contributing insurance on the property."

This is called the "Contribution Clause" or "Reduced Rate Clause." The percentage left blank is 90 if the amount of insurance covers buildings and contents as a whole; or 80 if buildings and machinery are insured in an amount separate from that which covers stock. Consider the following conditions:

a. Buildings and stock separately insured; the former for $6000, their value being $10,000. A fire causes a building loss of $4000. The first provision of the clause limits the amount of insurance to be collected to $\frac{6000}{0.80 \times 10,000} \times \$4000 = \$3000$.

b. With the same insurance and valuation, let a blanket policy be assumed, covering buildings and contents (aggregate valuation $10,000, amount of policy $6000). The insurance company's liability is $\frac{6000}{0.90 \times 10,000} \times \$4000 = \$2666.67$.

In the first case, a partial loss of $4000 would be completely covered only when the policy read for $8000; or, in the second case, for $9000. Most losses are partial losses, and most policies give only partial protection. The contribution clause (which is usually accompanied by a reduced rate) virtually makes the assured a partner with the insuring company, compelling him to assume part of the risk.

While buildings or structures are in process of erection, both owner and contractor have insurable interests therein. There are two ways of protecting these interests. In some contracts, it is provided that the contractor shall "maintain insurance policies amounting to.... per cent. of the actual value of all materials or completed work, payable to owner or contractor as interest may appear." If a fire occur before the owner has made a payment on account, insurance adjustment is purely a matter for the insurance companies and the contractor If, however, he has made payments, his interest in the insurance policies is evidenced by the acknowledgements of such payments. The second method is to stipulate that the contractor is to protect his own interests only. The owner then sees to it that every payment he makes is at once supplemented by a policy of insurance in his own interest. The contractor's bond is a warrant against delinquency on his part.

ship: money, technical knowledge or skill, commercial associations and acquaintances or the like; it is not necessary that all contribute money. All partners, however, participate in profits in such proportion as is agreed upon.

Unlike a corporation, a partnership is not a legal entity; it is obliged to act (in formal matters) through its individual members. The objects and scope of the partnership should be defined in its contract; but the members should consider also what presumptive scope it may have, since the public would be warranted in dealing with one of the partners in all such matters and the partnership might be bound by contracts made with the public by an unauthorized partner even though the subject matter of such contract were not one contemplated in the scope of the partnership. The acts of the partnership are determined by a majority vote or majority interest of the general members; special partners have ordinarily no active voice in the control.

A man may become a member of a partnership without desiring it or even knowing it. If he advance money, expecting to share profits and losses, he becomes legally a partner of the man to whom he advances the funds; and bears the full responsibility of a general partner in that individual's acts.

A partnership may be terminated by the date of limitation written in the contract; it is necessarily terminated by the death or insolvency of a member; by mutual agreement; or by judicial action. A partner cannot assign his partnership interest to another. He must call for a distribution of assets and retire. If he become insolvent, his creditors call for such distribution of assets in order that they may reach his share. When a partner is determined to retire, and a basis of settlement cannot be reached, he may ask the courts to appoint a receiver to wind up the business. Partnerships of two are sometimes dissolved in this way: one member fixes a price at which he is willing either to buy or sell the business; the other then decides whether *he* will buy or sell at that price, and produces the money or retires as the case may be. Upon termination of a partnership, the assets are distributed in the following order: the debts of the firm are paid; any money *loaned* by its members to the firm is repaid; the capital put into the firm by the members is repaid; and any remaining assets are distributed in accordance with the proportions agreed upon for division of profits.

The Corporation

A corporation is an artificial person, created by legal process under certain regulations fixed by the various states. Unlike a real person, it may engage only in such acts as its charter prescribes. The existence of the corporation is evidenced by the *charter*, granted at the petition of such persons as are interested. These persons and their successors have no unlimited individual liability for the acts or debts of the corporation; an officer may, however, make himself liable by committing an unlawful act.

This artificial person or legal fiction is empowered to engage in certain kinds of business, sometimes on condition of making certain reports regarding the general outcome of that business to the state which creates it. It is owned, in most cases, by a large number of individuals called stockholders, whose extent of ownership is evidenced by the number of shares of stock they hold. The total number of shares to be issued is stated in the certificate of incorporation. Stockholders participate in earnings and in the management in proportion to their stock ownership. There may be two classes of stock, preferred and common; the former may have certain prior rights in any eventual distribution of assets: it usually confers no voting power; it may be guaranteed a certain dividend out of each year's profits before any dividend is paid for that year on common stock. If a continuity of such dividend is guaranteed (unpaid dividends being a lien prior to any payments on common stock) the preferred stock is called *cumulative*.

The management of the corporation is in the hands of its directors, elected by the stockholders, and more directly still in charge of officers elected by the directors. Ordinarily, the individual liability of any stockholder in the affairs of an industrial corporation, whether he be an officer or not, is limited to the nominal or par value of the shares which he owns. Unprofitable policies on the part of the corporation may wipe out the value of the common stock, but can do no further harm to its owner. It is obvious that to the ordinary small investor, stock ownership in a corporation has some attractions not accompanying general participation in a partnership.

Organizing an Industry on Corporate Lines

Suppose A to propose the building of a paper mill. He talks with B and C, who each contribute $50,000. The A. B. C. Co.

is organized with a capital of $1,000,000, divided into 10,000 $100 shares. Of these each of the incorporators, A, B and C, receives $100,000. The balance is put in the hands of A or his banking friends to sell. The treasury of the corporation contains $100,000 cash. No money is contributed by A; he is the promoter. His expert knowledge, or ownership of patent rights,[1]

[1] **Patents.**—Ownership of patent rights may give a controlling position in the market to many kinds of industry. Many concerns regularly encourage their employees to develop new inventions. The cost of securing patents is in such cases assumed by the company, while the inventor assigns to the company the right to use the invention in its business. This right is not in all cases an exclusive right.

A *patent* is a grant, by the sovereign power,of the exclusive right to make, use and sell any device that is pronounced to be new and useful—an invention. Mere "good ideas" do not constitute an invention; a change in size, the omission of an element, the substitution of equivalents, the introduction of new combinations without new methods of operation; these things in general do not confer patentability. A change in material used is a patentable improvement only when such change is associated with a variation in process. The new use of an old thing—unless in a distinctly different line of application—does not constitute an invention.

To be *new*, an invention must show present local novelty. An abandoned pre-use, or current use abroad, does not destroy novelty. The existence of old models or unpublished drawings does not stamp an invention as "not new." A thing practically useless becomes "new" when made useful. With these exceptions, a thing cannot be called new if a single individual has known and used it.

To be *useful*, the invention need not show superiority over existing objects; it need not be more economical. Beauty is regarded as utility. The use must be beneficial; things injurious to morals or social policy are not patentable.

The *application* for a patent takes the form of a petition to the United States Patent Office (a bureau of the Department of the Interior). It is in the formulation of the application that the skill and knowledge of the inventor count most strongly in his favor. He should thoroughly know the essentials and underlying principles of his invention, and should not assume that his solicitors will properly state them. The application is accompanied by drawings and specifications, both of which must conform to certain established rules. The drawings are merely illustrative; the operation of the invention is fully described in the specifications. The gist of the application is in the "claims" which terminate it. These are a statement of what the inventor conceives to be new and useful in his invention. They are framed by the solicitor with extreme care, and as carefully scrutinized by the inventor. A patent confers no rights not "claimed." Features not essential should not be "claimed" as part of the invention. Claims should not introduce unnecessary limits in description; if a part may be driven equally well by a gear, belt or chain, no one of these methods of driving should be specified.

Following the application, an *answer* is returned to the inventor by the patent office. This will cite previous patents, which the applicant must then examine. If he can show that his invention is not invalidated by such patents, the *issue* of patent will be made in due course. The period between *answer* and *issue* is the critical period in determining the scope and probable value of the patent on a useful invention. Claims may be disallowed; the applicant is bound by his original claims.

Several *appeals* are possible from the decision of the patent office officials.

A question of priority of two pending applications constitutes an *interference*. Interference litigation is highly expensive. It is conducted by attorneys who make a specialty of such work; rarely by ordinary patent solicitors. In usual procedure, each litigant submits a statement before seeing the application of the other. The burden of proof is on the later applicant. The underlying principle governing decisions seems to be that the man who *first conceived* the thing, *if diligent in perfecting it*, has a prior right to the man who conceived it later, even though the latter first worked it out.

The patent (which may cover an art, machine, manufacture or composition) gives an absolute property right which may on no ground be confiscated. It is an infringement to or brilliancy of idea, or ability to float stock, have induced B and C to put each their $50,000 against his talents, and all three accept equal blocks of the stock.

At this early stage, the concern is really worth $100,000, and it has stock obligations of $300,000. Now A goes out and sells the $700,000 of treasury stock at par, less a banking house commission of $100,000, taken in stock. The stock liabilities are now $1,000,000 and the cash assets $700,000.

Construction is begun. As soon as the land is paid for, it is mortgaged to a trust company and bonds are issued for as large a proportion of the purchase price as can be managed. Say the land costs $200,000; the mortgage and bond issue may be $100,000. As the construction of the plant proceeds, more bonds are issued, until at completion the works have cost $1,200,000; of which $500,000 has been paid out of cash in the treasury, and $700,000 is covered by first mortgage bonds. The plant now begins business with $200,000 of working capital. Its total assets are, plant $1,200,000; cash $200,000. Its liabilities are, stock $1,000,000; bonds $700,000. There is a deficit of $300,000, which is due to the cost of floating the enterprise.

make for one's own use a patented article without permission from the owner of the patent. This right is granted for a period of 17 years.

Foreign patents are in some countries granted for comparatively short terms. One result is that when the foreign patent expires the invention is imported. This "discouragement to home industries" is avoided by a provision of law which makes the United States patent expire *with the foreign patent*, should the latter be first obtained. The arrangement so works out that American inventors do not seek foreign patents excepting on articles intended to be sold abroad. A *reissue* is practically a new patent. If the inventor feels insufficiently protected, he may be permitted to surrender his patent and receive a new one, based on new claims, good *for the unexpired term of the original patent.*

A *caveat* is a filed description of a proposed invention, submitted as evidence of priority and diligence in anticipation of possible interference. Its effect is that the inventor is given three months' notice before any conflicting application is considered. The caveat lasts for one year, and the time may be extended.

The title to a patent may be impaired by a license or grant or by joint inventorship. A constructing mechanic is not a joint inventor. One who furnishes capital to an inventor does not thereby become a joint inventor. The patent should be issued in the inventor's name. Any inventor should keep a daily record of his plans and work.

Assignments of part ownership in a patent may confer great privileges. A proper assignment provides for profit-sharing and constitutes a virtual partnership. A *grant* gives exclusive proprietorship in some one state. An article sold in that state may be carried to and used in another. A *license* merely gives the right to make, use or sell, exclusively or otherwise, in a certain place for a stated time. In selling grants or licenses to corporations, the inventor must protect his interests by a formal contract and preferably also by becoming a member of the board of directors of the corporation.

A man employed to improve machinery is, so to speak, engaged as an inventor, and his inventions belong to his employer. If not so employed, his inventions may be his private property. But his title thereto may be impaired if he occupies himself therewith during time paid for by the employer.

"Trade secrets" are usually so easily infringed without detection that they are rarely patented. (See *Trans. A. S. M. E.*, xxix, 15.)

B and C each received $100,000 stock for $50,000 cash; deficit, $100,000; A received $100,000 for no cash; the bankers received $100,000 in commissions.

The works begins operation. The first year, its receipts are $1,500,000; its operating expenses are $900,000. It pays out of the gross earnings of $600,000, $350,000 for interest on bonds; and with the remainder declares a dividend of 10 per cent. ($100,000) on the common stock and puts away $150,000 as surplus or reserve. When this reserve has sufficiently accumulated, it may be employed to pay off bonds as they mature; or if the business bring in a higher rate of return than the interest on the bonds, the latter may never be paid, the net earnings being wholly distributed to the stockholders after the surplus has reached the desirable safe amount. In many cases, accumulated surplus is invested in improvements so that ultimately the physical value of the property may exceed its capitalization liability. When the reverse condition holds, the stock is said to be "watered."

A stockholder who wishes to terminate his interest in the company has merely to sell his stock. In a small local corporation this might not be easy; in a corporation whose stock is "listed" on the exchanges, it can be done in five minutes. The corporation itself can go out of existence only by disposition of its assets and the distribution of their proceeds to the creditors and stockholders. A corporation is a permanent sort of thing; deaths and bankruptcies do not destroy it.

When a corporation cannot pay its debts, including interest on its bonds, a receiver may be appointed by the courts to dispose of its assets. When bondholders are secured by first mortgages on the property, they have a preferred claim on such of the physical assets as are covered by the mortgage. They may apply for a foreclosure sale, applying the proceeds of such sale to paying off their bonds. Many properties must in the very nature of things be kept in operation. Railroads are an example. The least margin of earnings over operating cost will help pay bond interest. Bondholders will therefore keep the road running for this reason, as well as to help maintain unimpaired its physical value.

In case of bad management, the road may default in its bond interest, although with proper organization it need not have done so. The bondholders may then form a stock company to buy the property themselves under the foreclosure sale and reorganize it to suit their own views. This has been the history of more than one railroad.

In our previous illustration of the paper mill, an additional stock issue might be suggested on one of these grounds: to provide money for extensions or improvements; to make the dividend rate look less exorbitantly high; or to provide money for retiring bonds.

For the first of these purposes a new stock issue is perfectly legitimate, although a bond issue would accomplish the result at less cost and with less disturbance to the value of existing stock. For the second, if there is so large a surplus that enough is accumulated each year to pay the dividend on the proposed new stock, there should seem to be no valid objection on the part of present stockholders. If the surplus is small, the issuance of new stock will depreciate the value of present stock. The issuance of stock in order to retire bonds means that more earnings will be needed if a reasonable dividend is to be paid on the whole stock issue; for bonds bear low rates of interest, comparatively speaking.

Generally, therefore, increase of stock issue is not permitted excepting by assent of the stockholders; and it is quite common for such stock, when issued, to be allotted to present shareholders, at a reduced price, in proportion to their present holdings. If any of the stockholders are not in a position to purchase their allotments, they may sell their "rights;" and the value of these "rights" suggests one of the several ways in which large corporations sometimes "cut melons." For example, the Pennsylvania Railroad company issued a 10 per cent. allotment of new stock at par, when the market price of its stock was 122. The holder of 100 full shares had then the right to buy 10 shares at par; his "rights" were thus worth about $220, and were negotiable at some such price.

Forms of Industrial Organization

Although its immaterial organization is concededly the most important feature of the industrial plant, there is no part of its being in which standards differ more widely. The plan of organization will in all cases depend largely upon the men available to make that organization. Men cannot be purchased, like machinery, to comply with exact specifications. The seeker for men is in the position of one who in the wilderness searches for trees with which to make poles for his tent. He has a clearly defined ideal, perhaps, but does not expect to realize it. He takes what may answer for his purpose and adapts his design to his materials. Technically, the organization should be planned, and the men found who can fit in that plan. Actually, it is necessary—for a time at least, and often in permanency—to lay out an organization so as to most effectively utilize the talent available.

Moreover, ideals of organization will differ in different industries. The differentiating "fundamental ratio" suggested in Chapter II will account for variations in organization type as well as in equipment and policy. Take the case of a building contractor whose investment in plant is small (as compared with that of a manufacturer), but who turns over his capital several times in the year. His business is one in which the fundamental ratio is low. We may therefore expect that fixed charges will be a relatively small element in his cost and that his principal aim will be toward operative economy—low prime cost of constructive work which he undertakes. He will have a force of expert supervisors in the various trades and will hold these men or the best of them even in dull times. The salaries of such men become in a sense fixed charges, however; and if they are, as usually, a large proportion of his total cost, he will take contracts at small profit when necessary in order to keep the men employed. The rank and file of employees, both productive and non-productive, will be recruited or discharged rapidly as the work on hand warrants; practices which will be facilitated by including in the supervisory organization men thoroughly familiar with the different trades. He will have little use, however, for a high grade operating engineer to supervise his power expenditures or for a good shop mechanic to care for his scanty equipment of cheap buildings.

Building up the Organization

Of vital, if not in all cases of immediate importance, is the matter of developing men for positions of authority. No industry can be permanently sucessful unless consideration is given this matter. Some of our longest-existing and most successful corporations are noted for the attention which they devote to it.

The man trained in applied physical science—the chemist or the engineer—is admittedly the most promising subject for training in management. His education fits him to deal with the problems involved in the economical operation and care of machinery and in the effective utilization of material. To make his prospects certainties he must now demonstrate his capacity to handle men and to deal with those large questions of policy, which have been suggested, in a masterful way. A large proportion of graduates of technical schools (a proportion still increasing) occupy administrative positions in manufacturing and public service works. It would be interesting to examine the reasons[1] for this; some are, the ideals of thoroughness and detailed study which commonly prevail in our technical schools; the training in the *quantitative* weighing of evidence; the habit of drawing conclusions from comparisons; the emphasis laid upon the idea of efficiency; the use of instruments of record and graphical representations; the development of a thirst for information and a spirit of original investigation; the training in rapid execution; and the universal agreement to share experience which is characteristic of the engineering profession. These ideals are of course never fully realized; but they are approximated by the best students, those who later attain to positions of executive authority.[2]

[1] See the writer's paper, *Engineering Management of Industrial Works*, in the *Engineering Magazine*, 1901.

[2] **Technical Training, Its Successes and Failures.**—It is scarcely worth while to attempt to justify these assertions, which manufacturers generally have by their action shown that they believe. The young technical graduate is intermittently under fire, but pretty steadily in demand. The age from 20 to 25 is an uncomfortable age with any young person; one in which he seeks his level with some disturbance to surrounding bodies. College professors are not unaware of the deficiencies of technical training. They debate the subject more than anyone else (see, for example, the proceedings of the *Society for the Promotion of Engineering Education*). Their most common fault is perhaps that they are *too* eager to fit their courses to current demand.

Many works make special efforts to secure technically trained men, as either regular or "special" apprentices. They have great difficulty in finding a satisfactory number of men, and in keeping them when they get them. The college graduate already represents an investment of $2000 or so in training. As a rule he must be as quickly as possible, after graduation, a self sustaining producer. Some companies have been particularly successful in training such men for positions of authority. They pay them a living wage from the start, and expect to wait a little while for results.

Two classes of criticism have had wide circulation during the past year or two. With that one class which condemns wholesale all higher educational and professional training, in colleges and technical schools, for physicians as well as for engineers, we need not deal. The other class may be illustrated from remarks of Mr. F. W. Taylor, himself a graduate of a technical school (see *American Machinist*, Nov. 15, 1906, and *The Bent*, January, 1910).

Some works maintain special apprenticeship departments for the "breaking in" of young technical graduates. When in these a genuine and serious effort is made to so teach men the business that they may be fitted for gradual promotion to administrative positions, the results are good from all standpoints. In those works where because of lack of attention or the deliberate desire

Mr. Taylor finds that young engineering graduates are discontented and unhappy, not worth much for the first two years after graduation; that they lack an earnest and logical purpose; have had more liberty than is commonly granted to or is good for human beings; that they have been habitually idle: have not learned team work or obedience; have suffered by not coming in contact with men working for a living; that they are no "smarter" than even a poorly educated workman. He regards athletics (purified) as the one interest in which the student shows earnestness of purpose; favors the man who "works his way through college"; and recommends a six months' course in an outside machine shop early in the college course.

Mr. Taylor has trained several hundred technical men and invariably selects such men for large positions when he can; he concedes that those employers who have the most extended experience with them are the most eager to secure them; and we are prepared to concede most of his statements as statements of fact (though not of all the facts); looking to his avowed policy for a suggestion of the conclusion which all of the facts warrant him in reaching. We will go farther. The student's characteristic defects are evidenced even in his own "student activities," like athletics. He usually lacks the kind of ability that "carries the message to Garcia." He is a putterer, an atrocious waster of his own and other men's time; he thinks an excuse is as good as a result always, and his excuses are often quite transparent. He is prone to pity himself. He thinks he is woefully overworked, when he scarcely knows what real productive work is. He resents monotony, forgetting that practically all of life is monotonous. He is a mere absorber, not a producer.

(The young technical man should be interested in the results of a statistical research made by Mr. J. L. Gobeille into the causes for executive promotion. An analysis of a large number of cases showed the following approximate relative weights of various factors in producing increase of authority and salary:

Detailed knowledge and ability to design	25
Executive initiative ability	20
Total abstinence	15
Promptness	10
Versatility	5
Youth	10
American citizenship	10
Church membership	5

The present writer would put *intellectual alertness* as a foremost underlying qualification.)

These things are all in a measure true. So would they be true of any young man kept out of productive industry until the age of 23 or thereabout. Suddenly thrown into industry at that age, our engineering school boys are just old enough to be a little slow in self-adjustment. They are often dissatisfied, and think their employers unappreciative and exacting. Sometimes the employers are just that. They frequently do not know just what to expect of an engineering graduate; don't know how to use him. (It is worth while, this learning how.) They put him on work of mere boys while they make up their minds To discriminate between round and square pegs and holes is a great art.

Not all young engineers expect to enter the machine shop. That is only one field even for the mechanical engineer. An engineering course which unduly emphasizes the machine shop idea is one-sided. An engineering school aims primarily to develop a certain type of mind; it does not (though this is commonly forgotten) occupy itself exclusively with the question of the man's immediate earning power. Engineering education may be as truly liberal as any type of education that has ever existed on earth. Liberal, that is, in the sense of man-making.

There is an occasional type of engineering student that one would think would exactly suit the critics of his class. It is the man who is good with his hands, fond of the laboratory to commercially exploit the apprentice he is engaged on work in which he is immediately remunerative, without regard to his future, the results are wholly bad. The young man is led to expect something which it is not intended he shall receive. He had much better—perhaps had better in any case—go in with the rank and file under no special understanding or agreement, and get his head above the general level by virtue of capacity alone—if he can.

Organization Axioms

1. While the form of organization necessarily depends upon the personalities available, it should as far as possible be independent of fluctuations in personality. The loss of one man should not wreck the administrative machinery.

2. The duties prescribed for the elements in an organization

and the shop, apparently well-provided with common sense; but who hates problems and "theory" and prefers to compete with the hand-worker rather than become a genuine brain worker He may be the best man after graduation (if he graduates) for the first year or two. But he has missed the main point. He would have done better never to have wasted four years in school.

The characteristic weakness which the writer has found in young technical men is *timorousness.* They are actually afraid, strangely enough, to use what they have learned. Possibly criticism has unnerved them. A man should employ his knowledge, apply his "theory"; we cannot have too much of that theory which is an *explanation of facts by their causes.*

Men get about what they deserve in the world; so that the best justification for the technical school is in the records of graduates. Any bright boy can get an engineering education nowadays. To borrow money for the purpose is a wise and surely profitable investment. The sad difficulty, in many cases, is in the question of cost and time for preparation. The writer has talked with many men of mature age who would have been prepared to sacrifice all they had in savings and position if by doing so they could have pursued a real course in engineering; but, in the great majority of cases these men have had to be told that years of preparatory study would first be necessary.

Classification of Engineering Schools.—There is some confusion in the public mind regarding the comparative grades of engineering schools. There are good and—not so good—schools in all grades, but there is a fairly clear distinction between what is properly called an engineering school and what is (however worthy, rich or successful) the distinctly lower grade, trade or industrial school. The essential characteristics of the former are:

1. It is either part of a university or one of the few schools which teach engineering or applied science alone.

2. Its course will be of four years duration (in residence, instruction being daytime instruction).

3. It will confer bachelor's or engineering degrees; in some localities, as in New York, under state sanction.

4. It may be one of the "accepted" institutions (defined as "colleges") of the Carnegie Foundation. This is, however, a positive but not a negative test; denominational institutions and (originally) state universities were not included in the Carnegie list of "colleges." There were in July, 1911, seventy-two "accepted" institutions on the Carnegie list, but there are certainly more than seventy-two genuine colleges (technical and other) in the country.

There are a few of the highest grade engineering schools which admit graduates only to their courses; in these, the course of study may be one of less than four years. Perhaps the commonest ear-mark of the "technical graduate," properly called such, is some knowledge of the calculus; but it is probable that in the great majority of cases the extent of this knowledge becomes rapidly diminished with advancing years!

should be so automatically inter-related as to make minimum demand upon the extremely fallible human memory. If A forgets to send C to B, something should necessarily call B's attention to that fact.

3. Authority and responsibility should be clearly defined and coördinated. If A is responsible for the cost of repairs, B must not be allowed to order a new roof.

4. Every individual should be able to reach a "man higher up" without being obliged to travel far.

5. Organizations do not spring fully-armed from the head of the divinity. They must grow and adjust themselves, and should not be expected to grow too fast.

6. Great changes in form of organization should be made with extreme reluctance.

7. Close association and frequent conference between superior and subordinate, and among those of corresponding rank, should be encouraged.

8. An effective organization must stimulate by the force of example. Every man should have specific and ascertainable individual duties which all men can see that he performs efficiently.

9. Each man must be made to feel a sense of personal proprietorship in the work over which he has authority.

10. The atmosphere must be one of mutual consideration and appreciation. Orders are orders; business is not palavering; but it seldom pays to reveal the hand of iron when the glove of silk may cover it.

11. The system of administration must adequately reward the competent; and stimulate, penalize or eliminate the unfit.

12. It should provide a spur and prod for every man; not one that needlessly irritates him, but one that rouses him to do his best. After all, men differ but little in their capacities; where they differ is in the uses they make of their capacities.

The Differentiation of Responsibility

The writer's ideal of organization is that which makes each official an absolute monarch *in his field*. To work out such an idea, it might be said, implies ideal men. Yet it is practicable, or substantially so, to commit a given work to a given man, leaving methods to him but holding him rigorously accountable for results. Some of the factors which complicate this simple ideal may be mentioned:

a. **Unmeasured and Unproductive Work.**—The man who is responsible for the cost of repairs may also have the care of the fire-preventive equipment. The time and attention he devotes to this counts for nothing in his "record" as kept by the cost department. He would rather have nothing to do with it. Some men may have duties of such nature that no formal judgment of results is possible.

b. **Conditions Vary.**—The chief engineer may have his record spoiled by a coal strike which doubles the cost per ton. Consider two points: minor variations in conditions should be ignored. We may refuse to discuss them. We must all take chances. If

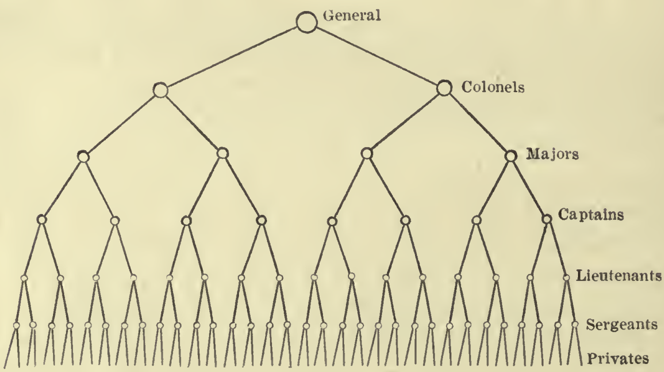


DIAGRAM OF PURE LINE ADMINISTRATION.

a man is always unlucky we had better try another man. Also: let us keep detailed records both of cost and of consumption. If it is the price of coal which accounts for a high unit cost of power, the records will show that to be the fact, and the chief engineer will not be blamed.

c. **Excuses.**—One department may hamper another by delays or wastes. This will be detected and should be prevented in a well-managed plant. Adequate system will detect delays and place the responsibility. No interested party's statement as to such delays, offered as an excuse for low efficiency, will be accepted.

d. **Punishment.**—Unless low efficiency is penalized the whole plant will degenerate. Lack of graded punishments is as serious a matter as the absence of a system of graded rewards. Reward and punishment must to some extent be matters of public knowledge.

Line Organization

If we consider the case of an army organized exclusively through the successive subordination of general, colonel, major, captain, lieutenant, sergeant and private, we have an example of pure line administration, which may be graphically depicted as on page 121.

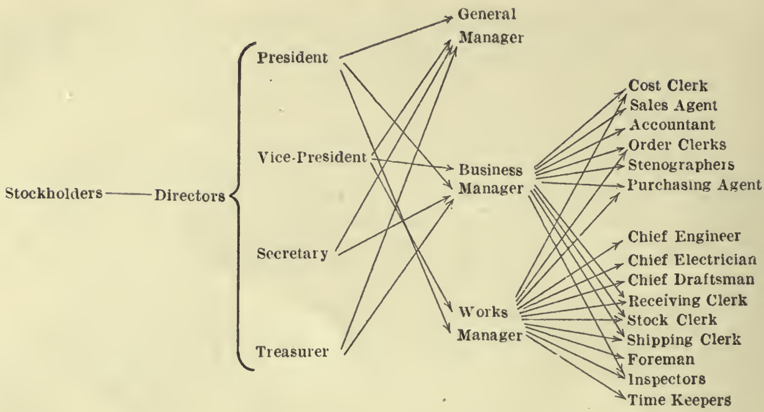
This is the oldest and most common form of organization, but probably never exists in the simple and rigid unmodified condition shown. The simplest and most usual modification consists in the introduction of a group of specialists advisory to the chief executive, but without formal administrative duties. The following, for example, is the organization adopted for a large electrical manufacturing works:

- President.
  - 1st. Vice-president.
    - Auditor.
      - Accounting.
      - Cost-keeping.
    - Legal.
    - Paymaster.
    - Purchasing.
    - Works manager.
      - Production clerk.
      - Superintendent, assistants, general foremen, foremen.
      - Superintendent of foundry.
      - Shipper.
      - Rate fixer.
      - Inspectors.
      - Works engineer.
      - Employment agent.
      - Storekeeper.
        - Clerical staff.
        - Stock men.
        - Receiving clerk.
  - 2nd Vice-president.
    - Engineering.
    - Sales.
    - Correspondence.
    - Construction.

In this scheme, the backbone of the line organization is clearly shown through President, 1st Vice President, Works manager and Superintendent. The balance of the administration is partly subdivisional and partly advisory. When industries grow very large, the general administration must be, as here, divided. The purchasing agent, for example, must be of the best type; so must the works manager; neither is big enough to boss the other. Each is a master in his field. There is a clear differentiation of authority and responsibility throughout the entire scheme.

But consider now the next plan (page 122).

Here there is no single responsibility anywhere between the



stockholders and the workmen. The general manager is a supernumerary. Each of the three managers has at least two bosses.[1] Not one of the four executive officers has definite control over one man. The cost and order clerks, purchasing agent, receiving, stock and shipping clerks and inspectors have each two superiors, which is just one too many. This is an example of extremely decayed line organization; the kind that grows up in the absence of planning. The strict line plan shown in the first (army) diagram would be greatly preferable.

Divisional, Departmental and Staff Organization

It is admitted, however, that strict line or divisional organization has its defects. Take the case of a railway. For each operating division there will be a superintendent, a master mechanic, a maintenance of way engineer, etc. If there are six divisions there will be six such sets of officials. We cannot afford to pay them the salaries necessary to obtain the highest grade men; they will be merely administrative clerks, without special or expert technical knowledge of the highest grade in their branches of the work.

Yet a large railway must have a thoroughly competent civil engineer in charge of maintenance of way. If it cannot afford one for each division, it will at least have one for the whole road, calling him, perhaps, the *chief engineer*. So also it will have a

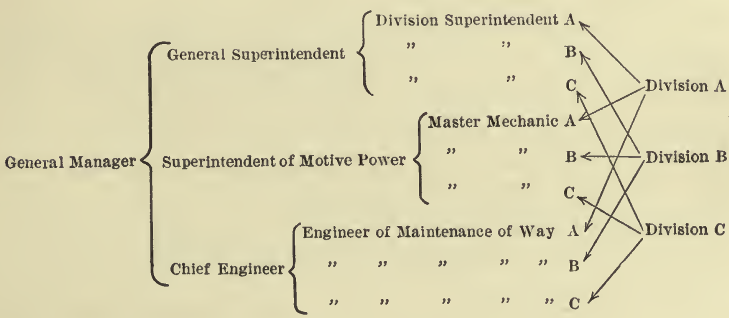
[1] There are two useful words—"boss" and "job"—of such great significance that their slightly colloquial flavor is to be deplored. Both are full of meaning, worthy of respectable association No substitutes quite take their place.

superintendent of motive power, a glorified master mechanic, to settle the larger mechanical problems for the whole road. The pure divisional, or line, organization was this:

General manager.	Division superintendent. Master mechanic. Engineer of maintenance of way.	Division A.
	Division superintendent. Master mechanic. Engineer of maintenance of way.	Division B.
	Division superintendent. Master mechanic. Engineer of maintenance of way.	Division C.

and this has in some cases been made (if possible) more divisional still by giving the division superintendent authority over his division master mechanic and engineer.

The revised plan follows. This plan must stand or fall on the ground of workability. Can the coöperation of the three division officers be obtained without destructive friction when the immediate superiors of these men are different individuals located perhaps a thousand miles away? In railway operation the answer is in the affirmative; first because of the strictness of discipline that has been inculcated for a generation and second because the direction of evolution has clearly defined the limits of each official's authority and responsibility. From the division officers downward the organization is of a nearly pure line type;



Possibly this condition of railway operation, or possibly the gradual trend toward independence of the engineer force (with regard to navigating officers) in steamship service, may have called attention to the need, in large organizations, for departmentalism. In such, it works best to have an engineer bossed by an engineer, an operating man by an operating man, and so on. One of the simplest applications of such policy is in the "committee system," an example of which is shown below. The

Works manager.
- Production department (planning).
- Cost department.
- Works engineer.
- General superintendent.
  - Electrical superintendent. . . . .
  - Mechanical superintendent. . . . .

↓

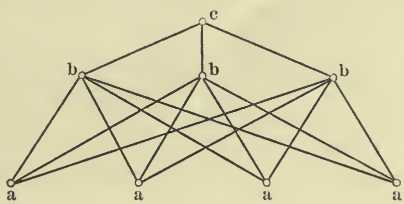
Manufacturing committee.

"manufacturing committee" is made up of representatives of the four works departments; it may include, also, subordinates of the general superintendent; for its function is deliberative and advisory, not mandatory. It considers proposed improvements, and questions of organization, method or policy; making (in spite of old-fashioned ideas of discipline) recommendations, through the works manager, to the executive committee of the board of directors. There may be subsidiary department committees as well, standing in the same relation to departmental superintendents as the manufacturing committee does to the works manager. The effort is made to have on these committees representatives of every class of interest in the works; and when these have representation on the manufacturing committee, every department is placed thereby in close informal touch with the works manager and the directorate.

The results are: a human contact with the man far down; a getting together of men which may help to offset departmental antagonism; a check on arbitrariness of superintendence. The chief aim is probably that which leads to departmentalism on railroads: that the maker of bricks may state his case to the maker of bricks and that the man who shovels coal may deal with one who knows what it is to shovel coal. The chief objection is that discipline may be impaired and the authority of the line organization undermined.

The ultimate result of departmental and committee control is an organization which tends to the form on page 125.

At c, is the executive in control. Under him are the staff advisers b, b, b, each of whom (like the three departmental chiefs on a railroad) is in charge of some one phase of the work. At a, a, a, a, are the men farther down. Each man has many masters: one, perhaps, who sees that he is on hand and keeps busy; another who tells him how fast to run his machine and what tool to use; another who compels him to keep his machine clean and properly oiled, and so on.[1] Whereas line organization branches out, staff organization (the type now considered) focuses. Staff organization puts at the top experts in each phase; the best men who can be obtained on power, repairs, cutting speeds, belts, material despatching, handling men, etc.



Line organization demands all-round men for the high positions, and when in the larger works such men of sufficiently high grade cannot be found, staff organization is essential. It has its defects. No man can effectively serve two masters, but the defects are minimized in exact proportion to the clearness of differentiation of function of the staff experts.[2]

The modern industry must, as we think, have both line and staff organization: the latter superimposed on the former, and differing from the former in that it accomplishes its work by persuasion founded on knowledge rather than by law backed by force. Staff experts must be exceptionally high grade men; but an effective line organization (if one ever existed) would demand men of almost superhuman characteristics.

Selling Systems

To keep his plant running, the general manager must sell his output. There are four recognized methods of selling the product of a factory:

a. To the consumer through traveling or located representatives.

[1] In introducing the more recent "profit-sharing" wage-systems, for example, four staff officials are usually contemplated; the *gang boss*, who despatches the work; the *speed boss*, the *inspector*, and the *repair boss*.

[2] Line organization, too, has its defects. According to Mr. Emerson's picturesque statement (too forcible, we think) it is usually "autocratic authority at the top—delegated authority and imposed responsibility all down the line, and anarchy everywhere."

b. To the consumer by mail.

c. To jobbers and dealers.

d. To agencies.

Selling was once regarded as one of those fine arts that defied rules and standards and could be discussed only by the initiated. It is now being reduced to a system and a science. Salesmen are formally trained from suitable raw material. Sales records are kept with the same detail and thoroughness as records of manufacturing cost. Selling is being reduced to a business basis, and bribery as an aid to accomplishment, with exorbitant expense accounts as necessarily associated evils, is now discountenanced. The salesman—especially the engineering salesman—is a higher type of man than he used to be. His is a difficult art, one in which the attainment of results is often chiefly a matter of chance; his position is hazardous, he is productively short-lived; and if he is successful he ought to, and does, receive a high reward.

The salesman must thoroughly know his goods and must believe in them. He lives closer to the factory than he used to; he keeps the factory in touch with the requirements and prejudices of the ultimate consumer. His manager will plan demonstration meetings and conventions where a carefully worked out program will be carried on for his benefit.

The Salesman's Record

The salesman's responsibility is to sell profitably. A record will be made of his gross sales and unit prices obtained. He may daily report all attempts, with reasons for failure or statements of success. He must know what ideal is in mind for him; what products it is most necessary to sell, and if possible what quantity should be sold in his territory in a given time. He must be posted on stocks carried and sufficiently so on productive conditions that he may intelligently discuss questions of time of delivery with his customers. The manager should know the distribution of consuming capacity, so that he can consider daily whether the channels for outflow of his product are being properly kept open. By prescribing the volume of sales in each territory he treats the market like his own plant, as a link in the conduit system of production. By prescribing limits of selling price and selling expense, and steadfastly adhering to these ideals, he virtually standardizes his profits in the same way as he aims to standardize costs.

Wholesaling

When goods are sold to dealers, it must be remembered that they are to sell them again, and that they must make a profit. Under ideal conditions, the manufacturer would sell to jobbers (wholesalers) only, or to dealers (retailers) only, as the case may be. Under most conditions, he has to sell to both and to the consumer directly as well. He must then "protect" the distributor by charging the other men a higher price; if the price to the consumer is $1.00, for example, that to the dealer might be 80 cents and that to the jobber 70 cents. The profit to the wholesaler is usually less than that to the retailer, because the former needs a less elaborate equipment in show-room and sales people; he deals with things in bulk. Usually the differentiation in price is made excessive; that is, in the example assumed, the wholesaler would expect to sell to the retailer say for 78 cents, and the retailer to the consumer perhaps for 95 cents.

In many industries, the product is always sold to the consumer, and no such differentiation of price is necessary.

Agency

Selling methods often give rise to problems connected with the subject of agency. In law, agency is a contract between one (a *principal*) who delegates authority to act for him, and another (an *agent*) who acts under such delegated authority. Agency may be *general*, covering all affairs, or all affairs of a particular kind, or *special*, when the scope is specifically limited. Limitations of agency concern outsiders only when they are made aware of such limitations. The act of the agent, within the prescribed limitation of his powers, is legally the act of the principal; the former has no individual responsibility. Agency may be conferred either prior or subsequent to the performance of a described act. Conference of authority to accomplish a prescribed result implies a grant of authority to use reasonable means necessary. An agent must not profit by his acts as an agent in any way other than that prescribed in his contract. A principal may and should disavow unauthorized acts of an agent. Public notice should be given of the termination of an agency.

The branch sales office of a manufacturing concern is usually in charge of a sales manager, who may be an agent empowered to contract for the sale of product. In some cases he has no such formal authority, ratification of contract being kept in the hands of the general officers. He may not even have authority to purchase necessary office supplies, but in many instances a sufficient number of precedents will accumulate to make the acts of the sales office binding upon the organization.

Consignments

Sometimes goods are sent to jobbers or retailers, not as the result of a sale, but merely that they may endeavor to sell them. Such a shipment is a *consignment.* Shipments of farmers to commission merchants are in the nature of consignments. When goods are consigned to some firm, that firm becomes for the time being, the agent of the manufacturer. Its authority and responsibility should be clearly defined, so that there may be no question as to the price at which the goods may be sold, their insurance, or other vital matter.

Integrated Industries

Industrial management has been in recent years profoundly modified by the growth of large corporations having many works. In the greater number of cases these have originated by the combination of existing plants, each owner or set of owners surrendering his or their ownership in one plant in return for shares in the integrated organization.

To harmonize conflicting interests and finally effect such a combination is a gigantic task, a task never quite satisfactorily completed. Each individual owner must be given what he agrees to accept as his just share in the total stock; many of them wish to have important posts in the management of the new corporation; many, perhaps, are bound by contracts with their officials (or do bind themselves at the eleventh hour), which the new organization must honor no matter how ill they fit in with its own plans.

In consequence, integration brings about problems, and may cause losses, peculiar to itself. The anticipated "economies due to consolidation" are not automatically realized. They must be worked for, like other good things.

The integration which we are considering is not of that kind occasionally practised throughout our industrial history, where neighboring industries have united in some one or more of their activities. It is an integration which ignores or abolishes geographical lines, putting under one management works located perhaps thousands of miles apart. One of the first of the new problems which it confronts has therefore to do with *transportation.*

An individual manufacturer usually has one plant to which he must bring all raw material and from which he must ship product. The integrated industry has many plants; and it must consider, in the light of transportation costs,

a. From which territory it may best supply each mill with material.

b. From which mill it should ship to each market its product.

A mine sells its ore to the smelter which offers the highest returns, transportation charge considered. A smelter buys its ore from whatever source supplies it most cheaply. Combine the mine and the smelter; the attitude of the new corporation toward other mines and other smelters will now be determined by a new policy.

Let us go further: A corporation owns many mines and smelters. The smelters produce product and by-product from the ore. There is a transportation cost between ore and smelters, between smelters and metal market, and between smelter and by-product market. Until conditions are standardized—and they never are completely standardized—a rather complicated calculation must be made in arriving at the price to be charged on a proposed production order—a calculation which must take account of the particular producing mine, the particular smelter, the cost of ore, the price realized for by-products, and the three freight rates.

Such problems as these warrant the creation of what is practically a new functionary under integrated organization—the *traffic manager* or *supervisor of transportation.* There are industries in which the transportation cost exceeds the cost of labor and supplies for mill operation. In these, the traffic manager is an important factor in production economy.

Cost keeping, in the large corporations, takes on a new aspect. Methods, systems, and records will be now compared and only the fittest allowed to survive. Records will become comparative as well as chronological. The unit cost of keeping costs—the expense of maintaining the statistical department, as related to the work which it does—will be greatly reduced because the work becomes more repetitive. A margin of funds may thus be available for employing a higher type of statistician than could be afforded by any of the old constituent works. In general, however, the chronological type of cost comparison (see Chapter III) will be given less prominence than before. Historical statistics are a dead language. Side-by-side comparisons of mill operation are alive, and the data for analysis of the facts they show are at hand.

The purchasing department, too, in a large aggregation of works, may be more competently organized and more economically administered.

Insurance becones a large matter; an expert may be employed to look after it. The business aspect alone requires special experience and training, and the construction work associated with sprinkler and hydrant systems and fire-resisting types of building demands some degree of engineering ability.

A high grade *chief engineer* to supervise the general department of power generation will be found needed; and in general, the whole tendency following integration is toward the introduction in the organization of high-grade *staff* officials, having jurisdiction not over geographical territory but over certain items of operation and cost.

A typical organization might be as below:

- President.
  - General manager.
    - Purchasing agent.
    - Insurance manager.
    - Traffic manager.
    - Chief engineer.
    - Statistical department.
    - Mill manager.
      - Mill superintendents.
  - Sales manager.
  - Accounting department.

Here the five non-productive officials subordinate to the general manager form, with the mill manager, the staff or advisory committee. Each of these five men has authority, within his sphere, over the mill superintendents. The last look to the mill manager for direction as to matters of production; to the chief engineer, as to matters of power and repairs; and so on. The system is not ideal; the authority of the five staff men may not be sufficiently decisive; the mill superintendents have too many bosses; but it is the best we have.

The New Type of Works Manager

The works manager of the old régime was a general supervisor, left comparatively free from matters of detail and occupied mainly with questions of policy. His responsibility, authority, and freedom of action were great. The precisely reverse condition has been brought about by integration; and men who developed under the old system do not easily adapt themselves to the new.

The works manager now is a local man with local interests, without the broad view necessary to enable him to decide questions of policy, concerning which, indeed, new data are now at hand. Instead of providing good judgment and courage for his subordinate engineer and repairman and purchasing agent, he is himself spurred from above by men of these kinds holding high staff positions in the general office. He must often do things in his plant which will injuriously affect his cost record, for the sake of the business as a whole. He used to expect just this sort of thing from his department chiefs—subordination of their departments in the interest of the whole works—but nevertheless the shoe pinches now.

In the past, operating cost was only one of the criterions by which the manager was to be judged. To-day it is everything. Once he was a general manager. Now he is a shop superintendent. At least this is the way he feels about it. If he is too old to learn, he retires; and the new type of works manager succeeds him. This is the man with the pruning-knife for costs, not the stout well-dressed magnate of former days, but the young man with his sleeves turned up who knows what is going on everywhere in the works, and why. He is an "executive officer"—one who does things; not a directing head. The place for the magnate—if he has a place—is in the general office; not in the bustle and noisy rhythm of the mill.

The Organization of Labor

It is proper to consider here the workingman's ideals of organization as well as the employer's, for workingmen are getting quite systematically organized. We may look at this matter in either of two ways: from the dispassionate standpoint of the student of industrial conditions, or from the selfishly interested standpoint of the employer.

The labor organization problem is almost always discussed with ignorance, prejudice, or indifference—or, strangely enough, with all three.

In the beginning of things industrial, employers were men who had been workmen and few shops ever worked more than a dozen hands. The early colonists who came to America in some cases aimed at a form of idle communism. We are indebted to Captain John Smith for the law laid down for their benefit: "he that will not work shall not eat."

Two hundred and fifty years ago wages in the various trades were in England fixed by statute. The invention of the steam engine originated or greatly stimulated the "factory system" of England, and since then industrial establishments have greatly increased in size. For many years England prohibited the export of machinery in the vain attempt to become industrial mistress of the world. The cotton gin and water-power, and later, iron and steel, made the United States an industrial power in its first century. During this century, prices and wages both increased, and the workman's standard of living was elevated.

The first "trade union" in the modern sense was founded in Scotland in 1796. Three years later the members of a union were tried for a conspiracy to raise wages. The year 1800 witnessed an Act of Parliament virtually prohibitive of labor unions; they were in consequence organized secretly and were guilty of many cruelly unlawful acts, to the great detriment of trade. The first crude attempt at a "Factory Act" for the protection of workers was made in 1802.

The trades were rapidly organized in the United States during the first decade of the nineteenth century. The English Parliament repealed its prohibitory law in 1824. The period from 1825 to 1850 was one of communistic or socialistic agitation everywhere. The first "welfare work" for employees was probably that conducted by Robert Owen at Lanark from 1819. During this period, papers and periodicals devoted to the interests of labor first appeared, and the "single tax" idea came into discussion.

Among reforms attempted by the labor element were the abolishment of imprisonment for debt, decrease in allowable number of working hours for women and children, increase in minimum working age, a uniform mechanic's lien law, the eight-hour day on government contracts, the establishment of bureaus of labor statistics, the passage of factory inspection laws, curtailment of number of apprentices, abolishment of productive convict labor, repeal of oppressive laws relating to garnisheeing of wages, imposition of liability for wages upon stockholders of corporations, supervision and regulation of "trucking" or "company stores"; and of course and perpetually, general decreases in hours of labor and increases in wages.

With all of these reforms excepting possibly those with regard to apprenticeship, convict labor and stockholders' liability, many people are in sympathy; probably even many employers, with reservations as to time, place and opportunity. Many of them have been accomplished, to the great benefit of the public. Working hours have been rightfully decreased; the day's wages increased; yet the cost of production cannot have increased else the standard of living would not have been elevated. The results (on the basis of this data) of labor organization have been on the whole good.

The present program of the labor unions (or of the friends of the workmen) includes:

1. Revision of our workmen's compensation laws, whereby the loss due to killing or maiming in industrial service shall be distributed over the industry rather than concentrated on the workman or his family.

2. An apprehensiveness toward increased production by profit-sharing systems of wage-payment or other methods. This fear underlay the old antagonism to machinery. It survives in the limitations of apprenticeship. It is based on a failure to comprehend that all our wealth is derived from our productiveness, that when costs are reduced, consumption increases in more than proportionate degree, and that increased productiveness ultimately raises the standard of living.

With any proposal to restrict production by direct or indirect means, either generally or in exceptional cases, we have no sympathy whatever. Such restriction, whether brought about by employer or employee, is the greatest of industrial misfortunes, and may evidence the deepest of industrial crimes.

3. The closed shop. This phrase refers to the shop or works in which union labor only is employed, as against the "open shop," in which both union and non-union labor are allowed, and the "scab shop" which employs non-union labor only. We advo-

cate the "open shop" as against either of the others because it alone aims to stimulate production by free competition.

Labor Warfare

The history of industrial strife between employee and employer is sickening. An organization of manufacturers was formed to oppose the labor unions as early as 1832. It antagonized the then "*ten*-hour" movement. Strikes were once considered indictable as conspiracy. Strikes, lockouts, boycotts, and violence of all kinds have been common, often without indictment or punishment for manifest crime, for eighty years. Labor unions have been united in great federations of national or international scope, and these have increased their already enormous power by combinations among themselves, taking into one organization men of all trades, united solely by their common interests as union workmen.

As with international war, the direct losses are the smallest. There is loss of wages by strikers and others, death and injury by violence and indigence, damage to property, loss of production, and great inconvenience and loss to the public. It was estimated by "Bradstreet's" that the loss to the country by the Homestead strike of 1892 was not less than $80,000,000. The coal strike of 1903 for a time doubled the cost of fuel in New York City.

A large proportion of strikes (possibly also of lockouts, although this cannot be stated) are based on what may be regarded as insufficient grounds, such as for recognition of the union, against objectionable officials and in sympathy with other strikers who may or may not have a real grievance. A strike for a reduction of hours or an increase of wages is simply one form of argument, and may be perfectly justifiable; yet it is too costly and destructive to be long tolerated as an ordinary measure by an awakened public. It is the manager's business to keep down costs; it is not the business of the labor unions to so increase production that costs may be kept down while wages are simultaneously increased. The interests of the two are dissimilar. Like two rival department heads, they need a common boss to dictate to both. And that boss is going to be—the public.

Compulsory arbitration is beginning to be talked about even in international affairs. It is certainly worth considering in affairs industrial. Organization of manufacturers to fight the labor unions is not the way to finally settle the labor problem. The British Engineering Trades Agreement of 1907 exemplified the proper way. The arbitration plan in Canada has developed good working features. Our National Civic Federation aims at conciliation and reasonableness of discussion. The road to industrial supremacy lies through industrial peace.

CHAPTER IX

Principles of Accounting

The results of industrial operation are expressed in their final form—in terms of dollars—in a special vocabulary constituting the practice of formal **accounting.** The history of an industrial enterprise is significantly recorded in its books of account.

Ordinary bookkeeping is a highly logical edifice reared on the foundation of a few arbitrary but simple conventions. Three rules underly the whole of it. With a thorough grasp of these rules and the application of a little common sense, any man may follow—may even in some cases devise—the plan of an ordinary system of accounts. These rules are:

(I)

Make Two Records of Every Transaction.—Every business transaction concerns two people or interests. One of these interests is our own. Whenever a thing of value passes from "us" to A, we *debit* (charge) A with the money value of that thing, at the same time *crediting* ourselves with the same value—because it has come from us. If the thing of value passes from A to us, we debit "us" and credit A. Whenever a debit entry is made, a precisely equal credit entry is simultaneously made to some other interest or "account," and *vice versa.*

The total of debit entries (always made on left-hand ledger pages) will therefore at all times equal the total of credit entries (on right-hand pages). Double entry bookkeeping is thus a simple device for checking the correctness of the accounts.

(II)

Subdivide "Us" into the Various Interests of "Us."—If this were not done, the account or interest "us" would appear too frequently for convenience and there would be no such classification of our interests as is necessary in order to show *in what respects* our business operations are going on profitably or unprofitably. Some of the interests of "us" are given the artificial titles;—

Cash, signifying the contents of the cash drawer or the bank account;

Merchandise, signifying goods in warehouse;

Bills receivable, which regards "us" in our aspect as a creditor (bills the payment of which is *receivable by us*);

Bills payable, having to do with our aspect as a debtor (bills the *payments* on which are to be made *by us*).

There is thus no account "us." If we pay out money we credit not "us," but *cash.* If we receive merchandise, we debit not "us," but *mdse.* If a man has received goods from us and, instead of paying cash, gives us his bill or note for the amount, we take care of the matter in this way:

Cr. *Mdse.*, for the goods;

Dr. *John Smith,* the purchaser, for the goods;

Cr. *John Smith* for the amount of his note;

Dr. *Bills Receivable* (notes receivable) with the amount of such note. Smith has given us his note, which is presumably good, so that his account is "squared." (Note that the complete cyclic transaction involves *four* entries.) But we have not received any money; we cannot debit *cash.* We therefore create an artificial individual, Mr. Notes Receivable. We give the note to him, debiting him with it. Some day, we expect, it will be paid; when it is, we will *credit* Mr. Notes Receivable and debit cash. The account of the former will then balance.

In the same way, if we give a note, we debit the person to whom we give the note and credit "Mr. Bills Payable," thereby virtually assuming that that fictitious individual has paid our debt for us. When we repay him by honoring the note we will debit him with the amount and credit cash. His account will then balance.

(III)

A debit balance represents either a resource or a loss; a credit balance represents either a liability or a gain. If the sum is one that we shall eventually either receive or pay, it is correspondingly either a resource or a liability; otherwise, it is either a loss or a gain.

When we debit an account, it is because that account has received something of value. If that something of value came from us, and the transaction is closed, no return being expected from the account in question, then the debit represents an expense, or *loss*. For example, we buy a broom, crediting cash for the money and debiting *office supplies* (one of the artificial subdivisions of "us"). The debit entry to office supplies represents an expense or loss, because we never expect to get back that broom (or anything else in lieu thereof) as value.

If the "something of value" debited came from some one else, say a supply of merchandise from Thomas Brown, it is in our possession as a *resource* as long as it is a debit. When the merchandise stock is drawn on for distribution, credit entries will be made which will reduce the debit balance in the same proportion as our resources in merchandise are reduced. In the case of the broom, the debit was a loss, because the article was immediately consumed.

We credit John Smith when he pays us money. If this is the close of a transaction, the credit represents income or *gain* from our last previous condition. But if this money comes to us as a loan which we must eventually repay, it is not a gain but a *liability*.

It is easy to determine whether balances represent resources or losses, liabilities or gains, if we carefully consider whether or not the transaction is completed.

Summing Up

At the close of a fiscal period we total the debit and credit entries to the various accounts, making a list of the balances. These are then grouped into the four classes, resources, losses, liabilities and gains. The net result of combining losses and gains (a debit or credit balance, as the case may be) is now transferred to an account *loss and gain*. Itemized balances are wiped out by entries "To (or by) Loss and Gain" and the corresponding contra-entries are made under *Loss and Gain* account. If the aggregate of balances is a credit (gain) then the aggregate of closing entries will be debits and *Loss and Gain* will be *credited*. All accounts (excepting those involving resources and liabilities) are now closed and a new set of books may be begun. Profits may then be divided among the owners by debiting *Loss and Gain* and crediting the owners.

The only accounts carried forward on the books to the next year are those involving resources and liabilities and the owner's accounts. A statement of resources and liabilities is made to show the condition of the business; the loss and gain account shows whether its operation has been profitable during the fiscal period.

Books of Account

Original entries of transactions are made either in the *cash book* or the *journal.* All cash transactions are entered consecutively in the former and the totals only appear in the *ledger,* which is the final record. The cash book is virtually a "page torn out of the ledger," kept separately in order that the large number of "cash" transactions may be concentrated and summarized in the final record.

Inventory

An account like *merchandise* might at the end of the year show a debit balance (loss) were not consideration given to the *amount on hand* as shown by examination or inventory. Unless we have sold merchandise aggregating in value the cost of that which we have purchased, there will be a debit balance. Inventory shows this debit balance to represent something physically existing; the merchandise transaction is not closed, so that the balance represents a resource instead of a loss. But how shall we ascertain and show what the *profit* through the sale of merchandise has been?

The method is thus: Assume that our purchases of merchandise aggregated $4000. One-half of this stock has been sold at a profit of $1000, bringing us in $3000. The merchandise account now stands charged with $4000 and credited with $3000, leaving a debit against it of $1000. We ascertain by inventory that our stock of merchandise is worth (at cost) $2000. On the credit side of the merchandise account we write,

By inventory . . . $2000.

On the debit side we write,

Profit on merchandise—to Loss and Gain . . . $1000.

The account now balances. But the contra-entries have not been made. These are, for the latter, a credit entry under Loss and Gain of $1000; and for the former, on the "merchandise" page of the *next year's ledger,* a debit entry "to inventory,"

$2000. This throws the account again out of balance; but the debit balance now represents a *resource*—stock on hand; and is carried forward as such during the next fiscal year.

Example

We may sum up all of these principles by considering a simple illustration. A and B engage in business, each contributing $2000. The entries are,

Cr. *A*, stock account,		$2000
Cr. *B*, stock account,		2000
Dr. *Cash*,	$4000	

The business starts with resources of $4000 and liabilities of $4000. Now assume the following transactions:

(I)

We buy a desk of J. Smith for $50, paying cash.

Cr. *Smith* by invoice for desk,		$50
Dr. *Office Fixtures*,	50	
Dr. *Smith* to cash,	50	
Cr. *Cash*,		50

Smith's account balances.

(II)

We buy merchandise of T. Brown for $1000, giving a note.

Cr. *Brown* by invoice for mdse.,		$1000
Dr. *Mdse.*,	$1000	
Dr. *Brown* to note,	1000	
Cr. *Notes Payable*,		1000

Brown's account balances; our stock of merchandise is a resource, the note we have given is a liability.

(III)

We sell $1500 worth of merchandise to A. Green for $200 cash and a note for $1300.

Cr. *Mdse.*,		$1500
Dr. *A. Green* to mdse.,	$1500	
Cr. *A. Green* by cash and note,		1500
Dr. *Cash*,	200	
Dr. *Notes Receivable*,	1300	

Green's account balances; we have a resource in the note receivable by us.

(IV)

We sell $200 worth of merchandise to R. Lee.

Cr. *Mdse.,*		$200
Dr. *Lee,*	$200	

Payment has not been made by Lee and his debt to us is a resource.

(V)

We pay the stenographer, Miss Kane, $15—salary for one week.

Cr. *Cash,*		$15
Dr. *Miss Kane,*	$15	

Miss Kane's services virtually balance her account; the technical debit balance which appears is a loss or expense.

Closing

We have now reached the end of the fiscal period. The following accounts are open:

1. Cr. *A*, stock account,		$2000
2. Cr. *B*, stock account,		2000
3. Dr. Cash,	$4135	
4. Dr. Office fixtures,	50	
5. Cr. Mdse.,		700
6. Cr. Notes payable,		1000
7. Dr. Notes receivable,	1300	
8. Dr. R. Lee,	200	
9. Dr. Miss Kane,	15	
	5700	5700

Our trial balance thus checks. We count the cash to ascertain that we actually have the $4135 that the books call for. We examine our office fixtures and merchandise and find them worth, respectively, $40 and $200.

These two accounts are then treated as follows:

Office Fixtures

Dr. to balance,	$50	
By depreciation,		$10
Forward—by inventory,		40
	50	50
Brought forward—to inventory,	40	

Depreciation

To loss on office fixtures,	10

We now have two accounts instead of one; the debit balance of $10 to *depreciation* is a loss; the debit balance of $40 to *office fixtures* is a resource and heads this account for the next year.

Merchandise

Cr. by balance,		$700
By inventory,		200
To loss and gain,	$900	
	900	900
To inventory,	200	

The inventory balance of $200 starts the account for the next fiscal period. The $900 has still to be entered in Loss and Gain account. Remembering this, we draw off the balances as follows:

Loss and Gain

To loss on office fixtures (depreciation),	$10	
Merchandise,		$900
Miss Kane,	15	
	25	900
Balance, which may be distributed to the owners of the business,	875[1]	
	900	900

Resources

Cash,	$4135
Office fixtures,	40
Mdse.,	200
Notes receivable,	1300
R. Lee,	200
	5875

Liabilities

Stock accounts, A and B,	$4000
Notes payable,	1000
	5000

[1] This is not an entry, but a memorandum.

The total debits still equal the total credits. The necessary contra-entries to Loss and Gain balances will of course have been made to the respective accounts. The net result of the year's business has been a profit of $875 available for the owners, and an increase in net assets which is also necessarily $875.

Secondary Statements

This illustration describes a mercantile business. Practically the only "operating expense" considered was the $15 stenographer's salary. In a manufacturing business, operating expense may be the largest item of cost, and this is often greatly subdivided. The accompanying is an example of the sort of statement (page 144) which might be made from the data furnished by the books of account. It is not a wholly satisfactory statement, because the inventory adjustments do not specify the special accounts to which they apply; these were probably mainly *repairs* in the first instance and *fuel* in the second.

The data on which the bookkeeper works are: invoices from shippers or to customers, the payroll, stock material reports, department reports, the collection department's records, etc. No unchecked document is regarded as sufficient evidence for a ledger entry.

The financial operations of a corporation are usually summed up in a statement which gives

1. Gross earnings (receipts).
2. Operating expenses, direct and indirect, including taxes.
3. Net earnings, $=1-2$.
4. Fixed charges (interest on bonds).
5. Surplus or gross surplus, $=3-4$.
6. Dividends, common and preferred.
7. Net surplus, $=5-6$.

The net surplus for any given year may of course be negative (a *deficit*); dividends or even bond interest being paid from a previously accumulated surplus.

In statements of resources and liabilities, a special memorandum is sometimes made of what are called "Quick Assets"—those which are cash or may be readily converted into cash, like notes and bills receivable, some merchandise or material, marketable securities of other companies, etc. Land, buildings, machinery and patent rights are examples of resources not regarded as quick assets, and not readily available for use in case of financial emergency.

NATIONAL EXTRACTION COMPANY

MANUFACTURING EXPENSE FROM ELEVATOR TO TANK

AUGUST, 1911

Plant			
Superintendent		$ 625.84	
Watchman		581.78	
Lighting		10.93	
Mill expense		789.86	
Repairs		7,657.90	
		9,666.31	
Deduct inventory not used		1,451.66	$8,214.65
Steam			
Fuel		3,063.10	
Water rent		162.66	
Engineers		1,298.16	
Firemen		609.99	
Handling coal and ashes		202.97	
Engine and boiler repairs		1,329.24	
Cylinder and engine oils		50.22	
Helpers		380.30	
		7,096.64	
Add inventory used		1,205.36	8,302.00
Labor			
Foremen		428.44	
Pressmen		1,804.39	
Moulders		1,932.44	
Cake strippers		1,501.00	
Packers		704.43	
Miscellaneous		2,808.91	
Temperers		218.17	
Trimmers		147.49	
Filterers		281.60	9,826.87
340,359 bushels seed crushed			26,343.52
1 Bushel average		.0774	
Plant	0.241		
Steam	0.0244		
Labor	0.289	.0774	

Selling Expense from Tank to Bank

1,937,335.06 gallons oil sold	
Barrelling, net	$30,659.90
Boiling and refining, net	1,925.89
Discounts and allowances	5,503.75
Freight and drayage	19,118.69
Selling expense (managers, salesmen, etc.), net	12,120.45
Executive expense (managers, office salaries, etc.)	14,778.74
Interest	20,472.64
Insurance	3,785.78
Taxes	3,562.38
Contingent fund	923.37
	112,851.59
Per gallon	.0582

The statement below shows the form in which the final reports of railway companies are usually made. In this particular case (that of a first-class road) gross earnings show a fairly steady increase, and the percentage of net earnings is high. Maintenance expenses have been increased, but the increase in gross earnings has been in larger proportion. The trend of gross earnings accounts also for the decreased proportion of fixed charges. The freight business of the road seems to have risen from a low ebb in 1902. The "Appropriation of Gross Income" and the first two lines of the table of "Statistics" are particularly significant when comparisons are made between different roads.

DELAWARE, LACKAWANNA AND WESTERN R. R.

Year	Average miles operated	Gross earnings
1896	771	$21,403,506
1897	771	21,002,017
1898	771	22,168,344
1899	771	21,325,122
1900	771	20,887,763
1901	771	23,507,634
1902	771	21,398,764
1903	770	29,180,964
1904	770	28,701,991
1905	770	31,951,063

Income Account, Year Ending December 31, 1905

Average miles, operated, 770	Total	Per mile
Gross earnings	$31,951,063	$41,494
Operating expenses	17,827,974	23,153
Net earnings	14,123,089	18,341
Miscellaneous receipts	3,938,963	5,115
Total net income	18,062,052	23,456
Fixed charges	6,536,137	8,488
Surplus	11,525,915	14,968

Operating Expenses

	Total	Per mile
Maintenance of way	$4,640,207	$ 6,026
Maintenance of equipment	2,871,911	3,730
Conducting transportation	9,816,196	12,748
General expenses	499,660	649

Ratio of operating expenses to gross earnings, 55.8 per cent.

Miscellaneous receipts above include $3,295,426 net profits of coal department.

Appropriation of Gross Income

	1905	1904	1903	1902	1901	1900
For maintenance expenses.	20.9%	20.8%	19.7%	26.9%	22.5%	25.8%
For conducting transportation and general expenses.	28.7%	27.1%	26.7%	33.4%	30.6%	34.8%
For fixed charges	18.2%	20.9%	21.7%	30.4%	25.0%	27.5%
For surplus	32.2%	31.2%	31.9%	9.3%	21.9%	11.9%
	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

STATISTICS

	1905	1904	1903	1902
Ton miles per mile of road.....	3,826,713	3,526,933	3,598,454	2,247,883
Passenger miles per mile of road	508,363	477,235	461,509	410,691
Miles, second and additional main track.	480	480	480	473
Miles, yards and sidings........	795	756	691	696

CHAPTER X

PLANT: THE PHYSICAL BASIS OF THE INDUSTRY

Systems for Carrying on Construction Work

The planning of an engineering works may be carried on *a.* by the regular plant staff, strengthened by the employment of special men, *b.* by a consulting engineer or mill architect, *c.* by an engineering-contracting force, or *d.* by a firm of engineer-promoters. The objection to method *a.* arises from interference with routine work and lack of broad engineering experience, but it must often be adopted in special lines of manufacture or in case of extensions to existing plant. Method *b.* is most orthodox of all and the specialist in works construction is apt to possess a collection of valuable data unavailable to the proprietor or his staff. Method *c.* is simple and attractive but the proprietor's only protection against the diverse interest of the constructor lies in the latter's reputation. Under the fourth method, promoters frequently secure lucrative engineering (and often, contracting) profits by advancing money for construction. The business is one of money-lending rather than of engineering, and costs are often high.

General Principles of Plant Location

The layout of plant has not been reduced to anything like a scientific basis, but experience leads to a few well defined rules. Every feature of construction and equipment, as well as of organization and operation, will be found to be related to the "fundamental ratio" of value of annual output to value of plant. (See page 8.) The higher the value of annual output, in general, the greater will be the warrantable expenditure in construction.

Cost of land is seldom a determining factor in location, and even when it is so, this is frequently not a matter which the designing engineer is required to consider. When the cost of material is an important item in the business, the proper selection of a site is of vital importance. Land is often given away to induce manufacturers to locate along a specific railroad or in some growing town: sometimes a bonus is paid the proprietor in addition. In most cases, *transportation facilities* are a first consideration, although of relatively less importance where a valuable concentrated product is made and the labor cost is large, as in jewelry manufacture. Certain cities or districts like Omaha, Chicago, Minneapolis, St. Paul, Buffalo, etc., are strategic centers of transportation. Many plants have been erected near Niagara Falls because cheap *power* is there available. *Water power* has been responsible for the development of many Eastern cities. *Fuel supply* is of first importance in some industries, and this factor is responsible for much of the growth of Pittsburg. Certain industries depend upon an ample or special supply of *water;* a paper and pulp mill, for example, must usually be located on an unpolluted stream. Where bulky raw materials must be *imported,* a seaboard location may be necessary. Pure *air* must be sought in some industries.

A frequently preferred location is in the suburbs of a large city, where a five cent carfare brings an abundant labor supply within reach. The quality of this labor may be inferior, and the inducements of the city are apt to make workmen somewhat unsteady. There are well recognized centers of supply of men for various trades, as Paterson, N. J., for silk workers, Minneapolis for millers, Southeastern New England for boot and shoe operatives, etc. An isolated location, involving the establishment of a new industrial community, is often chosen for large works. Here the workman's cost of living may be kept low by "betterment" enterprises, which, although involving additional investment, may be made self-supporting. The time spent in construction must be actively devoted to a canvass for men; but when men are secured they are apt to remain quite permanently.

An urban or a suburban location has the advantages of municipal fire and police protection, water supply, sewerage system, and lower fire insurance rates; and the disadvantages arising from higher taxes, municipal ordinances regarding smoke abatement, etc. The avoidance of undesirable neighbors, present or future, is a factor to be weighed.

The general location being determined, the means for ingress and egress must be considered. Rail communication is preferred to water for nearly all purposes, the latter often being inoperative for part of the year. Safe approaches for employees must be conserved, and no peculiarity of construction should be contemplated which might cut off the plant from a fire engine.

Desirable Characteristics of Site

A level plot is usually the ideal, although for some purposes a sloping hillside makes gravity conveying economical. The direction of prevailing winds should be dwelt upon in the planning if comfort and high production are to be attained in hot weather. A well-drained soil is of advantage and facilitates trucking during construction. Soils differ widely in bearing power and cost for excavation, both of which factors seriously influence the initial expense for foundations. Low undrained spots are not necessarily objectionable, as they may provide a place for the disposal of waste.

The entire planning should be for an ultimate plant, even if a dozen times the size of that to be immediately constructed, and land purchases should be made on this basis. Land for enlargements is often held by abutters at prohibitive prices after a plant is once established. It is desirable at the start to purchase an ample tract or at least to secure long-term options on adjoining land not immediately needed. The size of plot necessary depends upon its shape. The importance of securing sufficient yard room for storage and various operations is often not fully realized. But while a purchase once decided on should be made liberally, the buying (and the construction as well) should not be carried on too hastily. Large savings in fixed costs may result from deferring expenditures until the opportune time.

Preliminary Planning

Even though the proprietor may have ideas apparently definite regarding the space to be provided for his plant (a condition most likely to exist when the new works is an extension or duplication of one already existing), the mill engineer should make it one of his first duties to critically examine this subject. If in active practice in this field, he will gradually accumulate a mass of statistics as to relation between floor area and output for various processes. These data never become complete nor are they ever sufficiently detailed. If they are based on reading rather than on original experience, they must be employed with especial caution, since differences in management, etc., may, even in plants working on the same products with the same machines, lead to decidedly different rates of output. For example, a shop in which day work was the rule might give only half the tonnage per unit of space that would be obtained where a scientific profit-sharing system of paying workmen was in operation.

Comparisons, when made, should be based on some adequate unit of output; generally, the tonnage. Where the output is diversified, but a single principal raw material is used, *its* tonnage may be the unit. In comparing locomotive works, statements of floor space should be related to tonnage rather than number of locomotives built; so also, of course, with shipyards. Tonnage is the unit for a paper or pulp mill, but a ground-wood-pulp mill may not be compared with a soda-process plant. In a linseed oil works, the consumption of flaxseed is the unit; in a locomotive repair shop, the number of pits is a crude but sufficient unit; in a saw and planing mill, the feet of product will answer for comparing plants working on similar grades; foundries making similar products of like materials may be compared on a tonnage basis, but a malleable iron pipe fittings plant should not be grouped with one making water pipe.

Marked aberrations and inconsistencies will be found in all such comparisons. These are due to a variety of causes, and are perhaps most noticeable in connection with storage and assembly departments. Nevertheless, after all discounting, properly analyzed space data is almost invaluable for approximate estimates; even drafting room and office space will be found, for each manufacturing process, to have some fairly well established normal ratio to output.

As many sets of figures should be compared as it is possible to obtain, average ratios of departmental space to output ascertained, and any extreme variations from average ratios separately investigated. These variations will usually be found to be due either to (a) special modifications of process or (b) errors in data. For example, one comparison showed a boiler shop to have an area of 4100 sq. ft. per unit of output, while the average of nine other shops making similar types of boiler was 3000 sq. ft. Investigation showed that the exceptional plant was making a large number of small boilers and also doing an excessive amount of hand riveting, both necessitating extra space. In another instance, a preliminary comparison of six engineering works making the same product indicated that one was using about half the foundry space per unit of final output that the others were employing. The statistician afterward recollected that the first plant *purchased* the larger proportion of its castings.

Besides ratios of space to output, there are other canons for determination of plant area. In certain industries (not usually those where heavy machinery is used) the space necessary depends quite directly on the number of workmen. In others, as in forge shops, a man and a machine form a unit from which both output and space may be determined. (We are not now concerned with space from the hygienic point of view, but simply as related to the man's needs as an element of the mechanism). Certain kinds of plants (*e.g.*, spinning mills), use machinery so thoroughly standardized that the floor area necessary for a given output is known with mathematical accuracy. The engineer needs simply to learn the dimensions and attachments of each machine. In other works, as in locomotive erecting shops, or the machine room of a paper mill, the machinery or product is so special that the plant must virtually be designed to contain it and no collection of general comparative data is needed.

In large, complex plants, particularly if some new variation in method or process is to be introduced, it will sometimes be found that no opportunity for bulk comparison exists. The plant must then be divided into elements and these elements separately considered in the light of data on like elements in various plants. Any uncertainty will then be reduced to apply to one or a few only of these elements. A paper mill, making its own lime and soda-process pulp, was to be located at a point where the bulk of the wood supply was of an extremely resinous nature, nowhere else regarded as fit for making pulp. Special arrangements had to be made to treat it. This special equipment having been decided upon, that particular department, and the lime-burning department, were designed to suit. All other departments were planned as usual; the screen, bleach, beater and other buildings were given such floor space as is usual for those operations in other plants making the same sort of paper with a corresponding mixture of fibers.

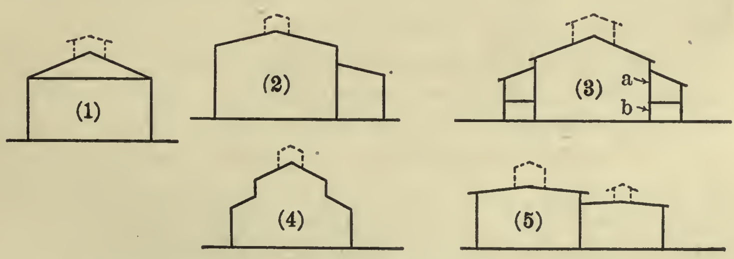
In these estimates and outlines, all figures should be drawn off for the proposed ultimate size of plant. There is no other proper way of "providing for extensions." The proprietor should fix the size of the final plant, the engineer should plan it, and the two should trim it down to the dimensions authorized for immediate construction.

Specific conditions may sometimes warrant radical departures from normal space ratios: the introduction of an improved machine; excessive cost of land, which may suggest unusual concentration by high-storied buildings; commercial factors indicating the advisability of providing excessive space; the purchase of outside power, making power plant and coal storage space unnecessary; division of the property as by street or stream, making normal arrangement impossible, and many others. The necessary provision for yard room is particularly dependent upon such factors. The amount of space needed for the temporary (and also for the more or less permanent) storage of raw materials as received, in proper proximity both to receiving route and point of consumption; of work in process; and of finished work; will vary notably with the activity of the industry, its steadiness or intermittence, the amount of capital invested, the occurrence of seasonal shut-downs, etc.

Building Standards

Practically all mill buildings are in plan rectangles or groups of adjoining rectangles. A trapezoidal form means more expense in proportion to the floor space, and in many plants would be of absolutely no more value than the inscribed rectangle, since a crane could not reach the extended corner. Shapes of greater irregularity are still worse.

The types of building used in large plants are three: the building of one high story, that of several stories of nearly equal height, and that of a single low story. The first type usually appears in one of the following forms:



The dotted lines represent optional longitudinal monitors with louvres or skylights. Crosswise monitors, or flat skylights, either longitudinal or transverse, may be used alternately or conjointly. This type of building is used only on large work, and its width is seldom less than 75 ft. The side spans in 2 and 3 may be single story, as in 2, or provided with gallery floors as in 3, on which light machinery only is used. The side span is not partitioned off from the main span at a and b, as that would obstruct the lighting of the latter. A high building of this type may usually be lighted from side windows if the width does not exceed 100 feet, but ordinarily some one of the forms of overhead light is provided for widths above 75 ft. unless the building is exceptionally high.

The one-story low building is used (a) for small work where land is cheap and separation of departments advisable, and (b) where unusually good light is necessary in all departments. In the latter case, the building must be narrow if side light is depended upon, but the best lighting effect is obtained by the use of the saw-tooth roof, with which there is no limit to the width of a building which can be adequately lighted. Ordinary low buildings may have a singly-sloped shed roof, or such a roof as that in Fig. 1, without the monitor.

There are arguments in favor of a building of several stories, where it can be employed. It economizes land, of course, but it decreases the cost of floor space as well. A five-story building occupying a given ground space requires somewhat more foundation (but only slightly more excavation and form work) and no more roof than one of a single story on the same space. For very heavy floor loads, the many-storied building is, however, impracticable. Light machinery only may be used on upper floors; and unless the upper stories are abnormally high, standard traveling cranes cannot be employed. The whole problem of transportation and communication becomes complicated with storied construction.

The necessary floor area and type of building having been determined, the width is next considered. In low buildings without top light, or buildings of more than one story, adequate lighting is usually impossible if the width exceeds 60 ft. The uppermost floor of a storied building may, of course, have top light from saw-tooth skylights or otherwise. The single story high building may be of any width, unless the height is beyond any normal amount—say in the riveting tower of a boiler shop. The determination of the desirable width depends largely on the crane service and on the sizes of materials and products to be handled. Overhead electric traveling cranes have been roughly standardized in spans of about 40, 55 and 70 ft. and it is usual in large works to accept these by adopting corresponding building spans. Those of 50 and 75 ft. should be sufficient for all the important buildings of an engineering plant. By combining these, widths of 50, 75, 100, 125, 150, 175 and 200 ft. may be obtained. A wider single span than 75 ft. is usually considered undesirable where traveling cranes are to be used.

The length of the building will suit the required area and determined width as closely as is compatible with the use of a standard "bay" (distance longitudinally from center to center of column), adopting preferably, for the latter, an even number of feet somewhere between 12 and 20, to suit standard material. A 20 ft. bay is common in large steel construction buildings. There are objections from an insurance standpoint to the construction of single buildings covering more than 40,000 sq. ft. of ground space.

Heights depend upon necessary crane clearances, the method of transmitting power, the nature of the work, and lighting requirements. In storied buildings without standard cranes, the floor heights will usually range from 10 to 18 ft. If a line of shafting runs along a side wall, 10 ft. would be insufficient. A locomotive erecting shop needs (a) 15 ft. of room above the floor for the locomotive itself, (b) room for a crane, including overhead clearance and (c) sufficient additional height for an economically designed roof truss.

Process Mapping

The arrangement of buildings must suit the process of manufacture, and it is often recommended that the process be mapped out and the buildings placed on the map to fit in proper points along the straight or curved process lines. This sounds attractively logical, but would sometimes lead to practical difficulties. Much depends upon (a) the value of materials at various stages of completion and (b) their nature, as fixing appropriate methods for handling them. In a cottonseed-oil mill, for example, the seed-grinding must precede expression of the oil, while refining must follow the latter: but so far as building arrangement is concerned, there is absolutely no reason why the refinery may not be on the opposite side of the seed house from the press room, for oil can be handled at an insignificant cost by pumping. Again, the questions of freight and market are often such that the refinery may be hundreds of miles distant from the rest of the plant. If the plant is one in which small parts are made in large quantities (particularly if the value of these parts is high), the question of arrangement (or even of shape) of buildings is of relatively small importance.

Much depends upon the quantitative relation between departments. A foundry is, of course, a feeder to the machine shop, and is fed by the pattern shop. To what extent each of these departments feeds another is to be determined by the *value* of the commodity fed. If the foundry is making a line of heavy repetitional castings, worth not much over a cent a pound, such a product can stand very little expense for handling, and the machine shop must be close to the foundry. If a pattern shop is making complicated, expensive patterns, which may easily be worth $1.00 per pound, the expense of handling is a small matter, and there is no need whatever to locate the pattern shop close to the foundry.

There is no way of handling cheap miscellaneous castings automatically. They must be lifted in and out of trucks or cars and conveyed in lots from one place to another. It is almost universal, therefore, for each machine works to have its own foundry, and to locate the foundry close to the machining department. By "closeness" is not meant, necessarily, adjacence; but closeness with reference to the method of handling. If castings are to be loaded on flat cars by a traveling crane, and then pushed by a locomotive to the machine shop, to be similarly unloaded in that department, it makes little difference whether the locomotive pushes the flat car 100 ft. or 1/2 mile. Either distance is "close," considering the means of transport. If the flat car is a light push car, to be manually handled, a half mile distance would not be "close." When very cheap materials (sand, for example) must be handled at all, they must be handled with extreme cheapness on account of their own low value. It is essential, then, to store them close to the department in which they are used. The labor for handling them may even then cost more than the materials themselves, yet there is no standard and accepted method of conveying these cheap materials, on account of the high cost of all conveying appliances as compared with that of the material.

Some cheap materials are, however, from their physical nature so cheaply handled that location has little to do with the scheme of the process. Crude oil is an example. This has a value, even at seaboard, of about 1/2 cent per pound. Yet two closely associated steps of the process of preparation for the market are often conducted at a distance of hundreds of miles from each other, since liquids can be readily and cheaply handled by means of a pump and pipe line.

Again, the physical nature of certain materials makes them practically non-transportable. The departments of a steam power plant cannot be separated beyond certain quite narrow limits, since steam is subject to condensation in transmission. Water is subject to no similar phenomenon, and we sometimes find, therefore, boiler feed pumps located a quarter of a mile from the boilers which they supply, although no process relation could be logically more intimate than that which exists between a boiler and its feeder. Electric power may be transmitted 100 miles; and it is not at all unusual to generate power in one city, and apply it to a shaft in another, many miles away.

Paper is a rather expensive commodity, readily transportable, while wood is cheap and expensive to handle. We consequently find wood-pulp paper mills always located near the source of wood supply rather than near the market. Pulp is cheaper than paper, but still not one of the class of "cheap" commodities. It is easily and cheaply transported. We sometimes find, therefore, the pulp-making and paper-making departments separated—perhaps a hundred miles or more—although logically the two should be together.

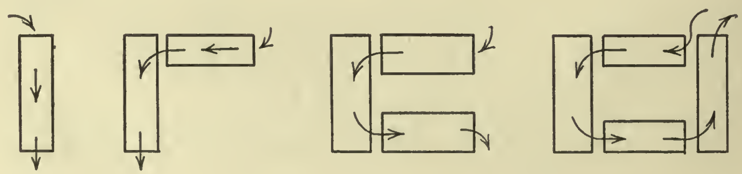
The importance of the relation between commodity cost and cost of transportation is evident even in the complexity of railway rates, in which there is an underlying principle that cheap materials take low freight rates. The general relation between the two brings us back to the fundamental relation between value of product and first cost of transporting plant. When this ratio is high, transportation cost ceases to be a determining factor in the arrangement of departments, and buildings may be grouped without reference to their logical sequence in the process. When the ratio is low, transportation is an important element, and related departments must be physically related.

Some ores, for example, are of very low value, and will not stand much transportation expense. To build a smelter at the mine is often open to serious objection. Mining is usually done in several separated districts, the combined product of which supplies a single smelter. The latter could not be strategically located with respect to all. To locate the smelter with respect to any one mine might remove it far from the supply of fuel, labor and other materials. The problem is solved by building "concentrators" at the mines. These condense the ore to a product which has a sufficiently high value to stand the cost of transportation, and the various "concentrates" are then hauled to a smelter, perhaps a hundred miles distant, for final treatment. The smelter is then located strategically with reference to its necessities as a manufacturing plant. A similar line of argument justifies the frequent separation of pulp and paper mills; in this case, however, the ultimate final product is often less valuable than that of the smelter, and the question of proximity to the market for that final product is an additional determining factor.

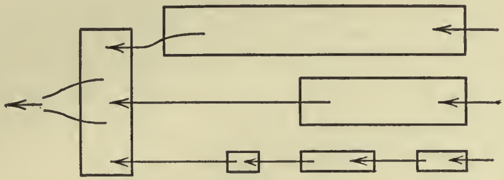
The actual rate of freight is often not the determining element in the cost of transportation by rail. Oil may be shipped either in bulk or in barrels, for example. Even at the same rate of freight, the dead weight of the barrel may result in a loss of 20 to 25 per cent. in transportation cost. Many oil producers and refiners therefore manufacture their product at some properly located point, and then ship it in bulk to their own tank stations in some distant city, where it is barreled in locally purchased barrels as required by local trade. Here a disorganization into two entirely separate establishments is found profitable. One of these, from a strictly logical standpoint, is unnecessary. Strict logical analysis evidently does not apply.

Grouping of Buildings

A strict process grouping of the simplest sort leads to a single rectangular building, or a group of such buildings arranged in a line, which may be either straight, or part of the periphery of a polygon.



It is far more common to find several distinct processes carried along at once, all culminating at a single assembly department. This provides groups or trains of buildings leading to a central erecting shop as in a locomotive works.



When buildings of determined size are thus grouped on the drawing board, it should be remembered that a unit division of yard space may often need to be planned for with the same fixedness of dimensions as a building. This is especially true when such parts of the yard space are to be commanded by cranes. One should consider the whole matter of storage requirements in a comprehensive way, note whether storage must be outside or inside, and treat both classes of space just as he would buildings in working up a tentative plan.

A structural steel fabricating plant perhaps best exemplifies the process type. Here there is one practically unmodified current from office, drafting-room, template shop, shears, planers and riveters, to the outbound storage yard. In a locomotive works, a series of processes—foundry and forge—leads to the erecting floor, usually by way of the machine shop.

In engineering shops, there are two distinctive methods of management which powerfully influence grouping. In the first, separation is by parts; in the second, by function. In the first, all parts which enter into the construction say of a boiler feed pump, are machined in one shop, whether they are composed of steel, cast iron, or brass. In the second, all brass parts requiring lathe work only are machined in one shop, whether destined to form part of a boiler feed pump or of a locomotive. The idea of a "process" is not the same for the two types of shop.

At the outset, it should be ascertained whether any necessity exists that two or more particular departments be adjacent; and it should also be determined what departments must be on ground floors.

Certain principles of insurance engineering must be considered. The limit of area that is allowable under one roof suggests the question of space between buildings. Such spaces should be ample; in general, not less than 50 ft. for main structures. Departments where fires are likely to start, like forge shop, foundry, paint and wood-working shop, should be separated from all the rest of the property, with wide intervening spaces. Similar separation should be provided for storehouses and other buildings in which the contents may be of exceptionally high value. Intervening spaces endwise should be multiples of the bay spacing; those sidewise may well correspond with building spans where no special reason exsits for the contrary. In this way a very few crane spans will answer for both outdoor and indoor cranes and greater interchangeability of handling devices will be possible.

Transportation Questions in Grouping

An outside crane runway will be far less expensive if supported on one or both sides against a building wall; otherwise, expensive A-frame columns or diagonal stiffening will be necessary.

A transfer table is a traveling crane without hoist or trolley, moving in a pit so that its upper surface is flush with the ground. It is used for moving very heavy loads, which are pushed on and off the crane bridge while the latter is stationary. Unlike an overhead traveling crane, a transfer table "kills" the ground space which it occupies, which then becomes an absolute loss of available room, and even a blockade to communication between departments. Its use is to be avoided where land is of high value. It does nothing that cannot be done by an overhead traveling crane, but the latter is neither as safe nor as cheap.

For light materials, if the floors are good, much inside transportation may be provided for by two or four wheeled trucks. If provided with a swivelling front axle, these will turn sharp corners. They should have ball bearings in all wheels. In restricted areas, the jib crane may be used both as a prime conveyor and as an auxiliary to other devices. The traveling jib has greater scope; instead of swinging on a fixed foundation, it is movable along a rail, the top of its post being guided. The monorail traveling hoist is widely applicable for long hauls as well as for general distribution. Main buildings will have standard overhead electric traveling cranes, sometimes several on one runway; or where the work is unusually heavy, more than a single runway may be provided.

Quick intercommunication between departments in the same or adjacent buildings is in general best secured by means of industrial narrow-gage railways. These use a very light rail section, and the cars employed are of short wheel base, to permit of sharp curves. Electric storage battery, or trolley, compressed air or even gasolene motor cars may be used, if any saving is probable thereby in labor expense or in time. Tracks must be laid out with ample clearances around columns, machines and the like, and every effort should be made to avoid grades. A level track is the only safe track. Short turntables are frequently employed in lieu of curves, which cut out much more valuable floor area than the turntable. Unless carefully designed, these tables will cause trouble.

Gravity conveying—hoisting all materials to top floors and then lowering them down from floor to floor until the finished product appears at the ground level—is of limited application, but should always be considered.

Clearances for standard railway tracks should be perferably 12 ft. in width and 15 ft. in height. The latter distance will clear a locomotive, but not a man on top of a box car. Unless 22 ft. of head clearance exists, bridge guards should be used. Track curves for yard service with six wheeled switch locomotives would best be made of not less than 300 ft. radius. The standard track gage of 4 ft. 8 1/2 in. is measured from inside to inside of rail head. (Crane track gages are measured center to center of rails.) When tracks run alongside of buildings, there is always more or less interception of light. This is of little consequence on "running tracks," but is often a serious matter if these tracks are used for storage of cars or are so related to the trackage system that trains are apt to be stalled thereon. In large works, a main siding should be installed, usually parallel with the railroad line. This gives room for the receipt of materials without imposing the necessity for immediately shunting them to their ultimate destination. A main shipping track is also desirable, being equivalent to just that much additional storage space for finished products, and permitting of a higher "load factor" in the shipping department. Connections with the railroad at both ends of main siding and shipping tracks eliminate much of the risk of congestion and delay. Track crossings are to be avoided, and should be unnecessary in any well arranged plot. Where crossings, drawbridges, etc., exist, as in many present plants, automatic signals may become necessary. These may be electrically or mechanically operated, the switches and signals, of course, interlocking. Tracks should not run into buildings on a curve. At least 100 ft. of straight track should be provided before reaching the building.

Locomotives for yard trackage may be either four-wheeled or six-wheeled switchers, the latter being usually much larger and heavier engines. (The small locomotives built for narrow gage industrial tracks, common in foundries, are usually four-wheeled.) Where the service is heavy, a turntable may be desirable. This should be installed at some readily accessible point. It may be operated by hand or mechanically. The largest locomotives require 80-ft. turntables. A housing shed for the locomotives is sometimes built.

The importance of thoroughly considering track arrangements cannot be overestimated. A complete list should be made of materials to be consumed, and means provided for bringing these in at points where they are to be used. In some organizations, both received and shipped material are supervised by the same storeroom force; the in and out trackage and storerooms should then be adjacent. In large works, however, a small part only (from a standpoint of bulk) of the material ever passes physically through the storehouse. The greater part may be kept elsewhere, possibly without even a roof over it. Testing room and laboratory should, of course, be considered in connection with receipts and deliveries of material or product to be inspected.

Other Considerations in Grouping

The disposal of liquid or other wastes must be provided for, including planning for drainage of rain water and from sanitary apparatus, purification of trade wastes and locations for dumps.

The location of the power plant is important. This must be considered from a standpoint of coal receipts, coal storage, ash disposal, condensing water supply, and economy of heating and power transmission. An approximately central site is usually preferred.

The general and sales offices, if a part of the works, should be rather isolated, away from noise, heat, odors and dirt. The works offices should be central. Due consideration must be given to the matter of location of "betterment" departments like restaurants, rest rooms, etc.

Finally, the easiest plot to lay out is usually of triangular form with the main trackage parallel to one side and track sidings entering at an adjacent vertex. Land cost is usually a small factor in total expenditure for a plant, and purchases should be made on a liberal scale. Several complete alternative layouts should be made for comparison and discussion.

Buildings: Types and Materials

It is wise procedure to provide, in advance of any detailed work on building plans, for all special machinery, power and heating equipment, systems of artificial lighting, ventilation, sanitation and fire protection. In this way much unnecessary expense and delay may be avoided. The cutting through of foundation walls for pipes, etc., is unprofitable.

The duty of an architect, as usually understood, is to make all sketches, general and detailed drawings and specifications, and to generally direct and supervise, the construction of buildings entrusted to him: usually, for a compensation which is a definite percentage of the cost of those buildings. When special engineering problems are involved, necessitating the coöperation of a mechanical expert, the cost of such expert advice is paid by the proprietor. In large enterprises, continuous local supervision is afforded by the employment of a "Clerk of the Works," who is engaged by the architect, but paid by the owner.

Mill buildings are usually designed by engineers. The duty of the designing mill engineer is then the same as that of the architect; and when architectural problems are involved, suggesting the coöperation of an artist, that coöperation should be called for by the engineer. Many questions of harmonious outline, appropriateness and general effect cannot be adequately dealt with by even the best engineer. If he censures the architect who "saves" the cost of engineering advice regarding power equipment, he cannot excuse himself for avariciously withholding a consulting fee from the architect for advice as to the development of a cornice.

In some states, no person may design and construct a building unless he be a duly licensed architect. Any qualified engineer may, however, obtain a license as an architect under the provisions of the law.

The carrying out of the engineer's plans may be by *a.* day work under engineering or proprietary supervision; *b.* fixed sum contract; *c.* cost-plus-percentage contract; *d.* cost-plus-fixed-sum contract; *e.* contract without stipulation of price. Method *a.* may result in the soundest construction, but there is usually a lack of sufficiently tested organization that results in high costs. Method *b.* is most common, but the interests of proprietor and contractor are almost diametrically opposed and too much depends upon the experience, honesty and shrewdness of the engineer. These objections have led to *c.* cost-plus-percentage contracts, in which the contractor does the work at cost plus an agreed percentage of profit. Here good work is in mutual interest; but economy is of no concern to the contractor, and the engineer's place in the organization may be even more commanding than under *b.* Cost-plus-fixed-sum contracts remove the contractor's incentive toward high cost of construction, and have in many cases been highly satisfactory. Method *e.* has been occasionally employed, where speed of construction was a prime factor, or where the proprietary and constructing interests were practically identical, as in the building of many railways.

From the type of timber frame commonly used in dwellings have evolved practically all forms of mill building. The parts are usually erected in about the following order: sills, floor beams, posts, angle braces, girts, plates, studs, window and door headers, ridge and supports for ridge, and rafters.

The modified "balloon frame" is that from which the self-supporting mill building is more directly derived. Here posts and studs are continuous from sill to plate, and the upper story floor beams rest on spiking pieces attached to the vertical members. The angle bracing must be especially thorough.

A timber mill building may be (a) practically like the balloon frame dwelling; (b) of "standard mill construction," all wood; or (c) of masonry and wood, "slow burning." Types (b) and (c) are the only ones to be considered in important design.

The simplest of the so-called "permanent structures" in which timber is eliminated from the frame has masonry walls supporting structural steel roof trusses, with a roof covering of metal, tile or boards—type (d). In the "masonry-filled-wall" type (e) the trusses are supported by steel columns and a light masonry wall fills the space between the columns. In the all-metal building (f) there are no walls, but an outside sheathing of corrugated iron, expanded metal and plaster, or asbestos composition, encloses the structure. Recent specimens now exist of the *concrete* building (g) which may be either monolithic or built up of small blocks. In either case the walls are hollow. Parts of concrete buildings which may at any time be subjected to tension, like floors, roofs, angles and corners, must be supported or reinforced by working in strips or fabrics of metal. A concrete beam is so weak in tension that at a very moderate ratio of span to depth it will break from its own weight. There exists an enormous number of "systems" of re-enforcing and many of these are controlled by contractors who instal them in buildings which they design and construct. Concrete buildings are fire resisting, rigid and permanent, if properly designed and put up.[1] It is estimated that in ordinary concrete mill buildings, about two-thirds the entire expense is for labor and timber for making the forms, the remaining cost being about equally divided between the concrete material and the steel. Low cost is attained by standardizing forms and so designing them that they can be taken down, transported and re-erected with minimum depreciation. Re-enforcing members must be protected by an adequate outside thickness of concrete; usually each inch of thickness will protect the steelwork about one hour during a fire.

The cost of mill buildings increases in about the following order of types: b, c, g (re-enforced), f, e, d. A far higher cost is reached when a building of type (d) has the steel fireproofed with terra-cotta tile or similar material; one that was formerly considered prohibitive, although under present price conditions, this is no longer the case.

The choice of a type is somewhat determined by the imposed loads and dimensions. Clear spans of 50 and 75 ft. are of course impossible with untrussed timber construction. With heavy floor loads, also, steel soon becomes essential, although with careful design, close posts, etc., an all wood building may support a load as great as 300 lb. per sq. ft. on each of four or five stories. A protected steel beam, however, is to be preferred to closely spaced timber beams.

Construction Contracts

A contract is an agreement between two qualified *parties* to do or refrain from doing certain specified things. In an equip-

[1] Cement becomes dehydrated and reduces to a dry powder at about 1100° F., but as this material is a nonconductor of heat, the damage from a fire of ordinary duration is apt to be confined to the surface

ment or construction contract, one party (the *contractor*) agrees to furnish certain machinery or structures to the other party (the *owner*) in *consideration* of the payment of a certain sum of money by the owner to the contractor. An ordinary contract binds the executors, administrators, successors or assigns just as it binds the original parties.

The place and date of making the contract may have bearing on its lawfulness, and should be specified. A corporation may not engage in undertakings not authorized by its charter. In some states a contract made on a Sunday or a holiday is unenforcible. Contracts involving certain minimum money values must be in writing to be valid. A contract for yearly employment is not recognized, in some states, unless in writing.

The usual preliminaries to a construction contract are (a) the issuance of specifications and an invitation to bidders, (b) the receipt of bids, (c) possibly counter-offers. Execution of the contract follows when an informal agreement has been reached. The contract price for work must be sustained by a "bid" or "proposal" price; if a bid is revised after it has been made, it should be revised in writing. A bid is binding only after it has been *received;* acceptance of a bid is binding on both parties as soon as such acceptance is *sent*, whether it is received by the bidder or not. A "conditional acceptance" is merely a counter-offer, a revised "bid." It binds its maker as soon as received by the original bidder. A contract is not completed until signed and "delivered" or mutually released. Lapse of time may outlaw a contract; *i.e.*, make compulsory performance impossible. The effect of a *seal* may extend the period during which the contract is legally enforcible.

Municipal contracts must usually go to the lowest bidder, bids being publicly opened. Such contracts may be ruled illegal because of non-compliance with statutory requirements as to advertising, etc. Contracts for work done under definite appropriation should never be made for the full amount of the appropriation, else compensation for extra work may be difficult or impossible of attainment. Public agents are not liable for negligence. Statutes of limitation do not operate against government. Informal municipal contracts are not recognizable.

In important contracts, whether public or private, *sureties* may be required. The surety is a reliable guarantor of performance—usually a company of large financial resources—and is of course compensated for its services. If the contractor defaults, the surety must carry on his work or otherwise relieve the owner from loss. The surety guarantees performance of specific obligations: if these obligations be subsequently changed, the guarantee does not apply.

The time of completion of contract is usually an essential matter. This may be guaranteed by the surety, or there may be a forfeiture clause, under which the contractor loses a certain part of his remuneration in case of failure to complete on time. Sometimes the forfeiture is a definite sum of money for each day's delay; sometimes there is a corresponding bonus paid for each day saved. Forfeitures may be imposed either as "liquidated damages" or as "penalty." The attitude of the courts toward the two differs.

Under a construction contract, the architect or engineer becomes the agent of the owner (see page 127). His responsibilities are regarded severely in law. He must not receive commissions from contractors or dealers (the owner may recover such if paid), must have no interest in the contract, and must not hold relations of any sort in conflict with those of the owner.

The contract price will frequently exceed the engineer's preliminary estimate and the actual cost of the work will almost invariably exceed the contract price. Some of the reasons are sufficiently obvious; planning is not an exact science. The better the engineer and the more definite the owner's conception of what is wanted, the fewer (assuming a proper allowance of time for working up the design) will be the *extras* or additional work necessary to complete the job beyond what is covered by the contract. Extras are an inverse measure of efficient planning.

The cause for excess of contract price over estimate lies in the illegal "pools" which have more or less generally prevailed among construction contractors. They operate as follows: A trustworthy individual is appointed as "secretary." Whenever a contractor prepares a bid he notifies the secretary. The latter in return tells him to "add *blank* dollars for the association." The amount of addition is a matter of conscience; 10 per cent. is not unusual. This is eventually divided either among the bidders or among all the contractors in the district. Sometimes a small proportion is generally distributed, while the greater part is divided between those who have been honored with the requests for bids. Occasionally a lazy contractor will ask the secretary to give him a safe bid for the job, which he does not happen to want. This saves him the trouble of making an estimate. The low bidder may be decided upon in advance and his may be the only estimate made. If there are contractors in the district who are not members of the "Association" it becomes a matter of some moment to know whether they are bidding or not. Sometimes a chance must be taken. The way out of this, for the owner or engineer, is to secure bids from such "scab" contractors if possible; even, when necessary, by going out of the district. But some of the building trade contractors have been nationally "organized" for the purpose described.

The *specifications* are a description of the work to be done under a contract. They are accompanied with *plans* or drawings, and a clause in the specifications should refer to the plans, specifically identifying them by number or otherwise. The contract should contain a clause incorporating the specifications. The contract includes the business agreement; the specifications describe in detail the work to be done. Both necessarily contain a number of general clauses, which few people stop to read. There is a "Uniform Contract" for construction work recommended by the American Institute of Architects and the National Association of Builders which contains a standard set of general clauses. There are in some standard forms provisions so unreasonable as to be ridiculous. They virtually amount, some one has said, to the statement from the engineer to the contractor, "if there is anything I have forgotten, you have got to furnish it anyway." But certain general stipulations are of course necessary; such as those relating to the method of authorization and basis for compensation of extra work; provision for arbitration; authority to make sub-contracts; responsibility for insuring and otherwise caring for material, and for personal injuries to workmen; compliance with local building ordinances; responsibility under mechanic's lien laws; and payments on account, which may be a fixed proportion of the value of work done, as estimated by the engineer, or a definite sum at various stipulated stages of completion of the work.

Valuations of Manufacturing Plant

"Value" is not a very definite property of matter. What we may call the value of a thing depends upon the purpose for which the valuation is made. A thing may be appraised at the price at which the owner is willing to sell or at that at which some one is willing to buy it; buildings with power and heating equipment or privileges may be valued for the purpose of determining a fair rent, insurance or tax rate. A property may be condemned for public purposes and the valuation is then made to determine what remuneration shall be paid the owner. It may be appraised as a physical entity on the security of which money is to be loaned;[1] the value is then that which would be realized at a forced sale; or for the adjustment of fire or other losses, in which case value will not exceed cost of replacing and may be less than this cost. In general, value cannot be absolutely determined excepting at the moment of a sale; two parties (whose interests are opposed) may at such moment be presumed to agree as to the value of the thing sold at that moment.

There are two general bases for approximate valuations of manufacturing plant. The first considers the property as made up of so many pieces of physical material, the values of which may be ascertained by comparison with similar materials elsewhere. If a factory building contains ten million bricks, it is not difficult to tell how much the bricks in the building are worth. The second basis of valuation regards the plant as one element in a productive enterprise, and determines its value from a consideration of the profits of the enterprise. Value in this sense has no relation whatever with cost. The first method seems definite and straightforward; but the value which it gives is not that at which the owner would sell or another would expect to buy. It is worthless as the basis of a sale, unless the plant is clearly unprofitable, and usually worthless even then. Moreover, it presents difficulties. It is a very difficult thing, for example, to determine what the *site* is worth. Regard must be paid not only to local real estate conditions but also to competitive conditions; the effect of the site on transportation charges. A bad location in this respect is equivalent to a mortgage on the plant. Questions of water supply, water-power, cost of power, tax rate,

When a corporation seeks to "float" an issue of bonds, many considerations will influence the purchasing syndicate in its judgment as to the safety of the proposed issue. There will be an examination of physical property by an engineer to determine its original and replacement cost; a consideration of the profits of the business by an auditor; legal and financial advice regarding value of intangible resources—patents, franchises, etc. The value of its securities in the market will be regarded, and the margin of earnings above proposed requirements for bond interest will be carefully considered. Good business judgment as to the market position of the industry is always sought for.

character of local municipal government, labor supply, cost of construction work, facilities for installing equipment, opportunity for safe disposal of wastes, prevailing hours and wages for workmen, probable nature of the future development of the neighborhood—all of these are factors which must be considered in valuing land alone. These or similar factors enter into the valuation of other physical elements; so that whether we wish it or not, we cannot fix a valuation for a manufacturing property without some consideration of its earning power.

Consider also the case of a hydro-electric company. Its plant might have cost, and as material be worth, $5,000,000, but if the flow of water were unexpectedly variable, one might hesitate before buying its bonds even when issued to the aggregate of only half that sum.

The first of the methods of appraisal invariably merges into the second. The second is fairer. If a plant by long good organization and management earns $100,000 a year, it may be worth $1,000,000 even though it cost only $300,000. Valuation on the basis of earning power puts a premium on efficiency. But it must not be forgotten that excessive profits may be due to excessive prices, and a valuation contingent upon unreasonable prices is hazardous because of the possibility of competition.

Under the second method, the value of the plant is not, however, a capitalized representation of its earnings: it is *the cost of that plant which, erected to-day, could under equally good management produce equally good results.* This is the value of the *plant;* not the value of the *business*, which includes, besides plant, an organization, with special and technical knowledge; good will, that is, outstanding public and private accounts and future increases therein which have been already earned by development expenditures; and possibly franchises, or special (often exclusive) rights to operate in and through streets or elsewhere.

Mr. H. L. Doherty (who has suggested much of the foregoing) lists the following classification of elements of physical and organization value in public service industries:

A. Real Estate.

B. Physical property, at cost less depreciation, based *not on books, but on inventory.*

C. Omissions, 2 per cent., to cover physical property not found.

D. Engineering and supervision, 5 per cent. of B and C.

E. Ordinary contingencies, as in construction, 10 per cent. of B and C.

F. Legal expenses during construction.

G. Insurance risk while building; public, employer's and fire risks before operating.

H. Allowance for piecemeal construction, 10 per cent. of B, C and D.

I. Interest while building, 6 per cent. of A, B, C, D, E, F, G.

J. Excess of actual over computed cost, as in construction, 10 per cent. of A–G, I.

K. Organization—printing, engraving, promotion (the last often as much as 8 per cent. on entire investment).

L. Working capital—stocks of materials—accounts receivable.

M. Unbilled product.

N. Operating organization salaries and expenses, prior to completion of plant.

O. Operating expenses in excess of earnings during development period.

P. Interest in excess of earnings during development.

Q. Cost of developing business not included in O and P, usually exceeding half the gross receipts for one year.

Power Valuations

The determination of the value of a water power privilege is particularly complicated. Such privileges are frequently condemned by municipalities aiming at the improvement of the water supply. In the celebrated Worcester case, the courts awarded the claimants (owners of the condemned property) $500,000 and interest for the loss of about 1000 horse power, which had been available during eleven months of the year. The claimants maintained that a horse power is a commodity having a definite ascertainable market value; that the acts of the city had confiscated such commodity, and they asked for damages, $1,500,000.

The city pleaded that the claimants had not lost a commodity, but what the law calls an *easement* to their estates. It maintained that the loss to the claimants was merely the difference between the original value of their estates and the value after the loss of the easement. It proposed to ascertain this difference by ascertaining the difference in cost of water-developed and steam-developed power. The case was, "Every water power's value is fixed by some steam engine."

There are arguments in favor of the city's case. The mills had not been deprived of power, but of *water*, with which they might have made power. Virtually, they were deprived of *coal*, because to replace the lost power they would have to buy coal. Figures obtained from 25 mills using steam power showed the cost of a horse power for a year to average $50.14. But the standard which the city aimed to establish is one that could not be applied. A horse power for a year from steam might cost $50 in a mill where the working day was of 10 hours, but it might as easily cost $100 where the working day was 24 hours. Should the one owner receive a compensation of $100 and another only $50, merely because the latter's was a 10 hour plant and the former's one running 24 hours?

On this basis, too, the water power might be given an excessive value. Not a dozen plants in New England have a constant flow of water throughout the year. Most of them maintain a steam plant in reserve. Their water power is worth (if we accept the city's contention) the sum of money which would have to be invested to maintain an equivalent steam plant in the same place, *less* the cost of the reserve steam plant which must be maintained for emergencies under water power service. Then there is the further complication of operating cost for such reserve steam plant, when it runs; and the possibility of using exhaust steam for heating still further confuses the whole question. A complete discussion of this interesting subject may be found in the *Transactions* of the American Society of Mechanical Engineers, Vol. XXVI, paper by Mr. Chas. T. Main.

Absolute ownership of water power privileges by manufacturing plants is perhaps less common than tenure on long leases, the power being developed by the leasing company. A common unit for the sale is then the amount of water which will flow through an aperture of given depth and area, with a standard "head" of water above the top of the aperture. The same device may be used for limiting the delivery to a mill which actually owns its right.

At Lawrence, Mass., about 10,000 horse power was developed at a cost of $1,300,000 for dam, canals and machinery. The fixed expenses chargeable against the development are about

$11.70 per horse power per year. It costs about $2. more to care for and maintain the equipment, so that the mills get their power for $13.70 per year. The cost of maintaining and operating a steam plant in the same district, including fixed charges, is about $21.80 per year. A credit of 25 per cent. of this, or $5.45, is made to the steam plant because it furnishes exhaust steam for heating, for which coal would otherwise have to be purchased. This leaves $16.35 per year, as the cost of steam power. The value of the water power (on the city of Worcester's basis) is then $16.35 – $13.70 = $2.65 per year; or, capitalized at 5 per cent. say, $53, per horse power. But if the price of coal should so decrease that the total cost of producing steam power were reduced $2.65 per year, or 12 per cent. (not at all an improbable fluctuation), the water power would on this basis have no value whatever. It would continue in use, however, because fixed charges on the development would have to be paid anyway; but it would not be saleable at its physical value.

EXERCISES

CHAPTER I

1. A paper mill runs 4 weeks on cartridge paper, producing 960,000 lb. at a cost of $38,400; then 6 weeks on "bond," turning out 720,000 lb., costing $50,400. What is the percentage difference in cost per pound of the two kinds of paper?
Ans., bond costs 75 per cent. more than cartridge.

2. The same mill, in order to determine relative costs, makes test runs of 24-hour duration on each grade, producing 20,000 lb. of bond and 40,000 lb. of cartridge. The cost of the day's operation is $1360 in the first case, $1575 in the second. Find the percentage difference of cost per pound.
Ans., bond costs 98 per cent. more than cartridge.

3. Which of the methods suggested in Exercises 1 and 2 is likely to give results more closely corresponding to usual costs? What difficulties arise in making cost determinations by either of the methods? Discuss the probable accuracy of estimates of daily total cost in Exercise 2.

4. A linseed-oil mill uses the *weight of oil output* as its cost divisor. During one month, it crushes 100,000 bu. of seed, yielding 17 lb. of oil per bushel, the working cost being $15,000 and the seed costing $0.867 per bushel. During the second month it uses seed costing $1.00 per bushel, crushes 110,000 bu. at a working cost of $16,000, and shows a yield of 19 1/2 lb. of oil per bushel. If the oil yield plus the cake yield aggregates 55 lb. per bushel in either case, and oil is worth 37 1/2 cents per gallon (7 1/2 lb.) while cake is worth 1 cent per pound, compare the profits for the two months and show that these have no relation to the respective unit costs.
Ans., in the first month the apparent cost of oil per pound is $0.0598 and the profits for the month are $21,300. In the second month the figures are respectively $0.059 and $20,300. Although selling prices have remained the same, the profits have decreased in spite of a decrease in unit "cost of operation."

5. A bushel of flaxseed costing $1.00 weighs 56 lb. and yields 19 lb. of oil and 36 lb. of cake. A ton (2000 lb.) of cottonseed yields 300 lb. of crude oil and 800 lb. of cake. If mill working costs are the same in either case, at the rate of 14 cents per 56 lb., and these products represent *all* the marketable product from the seeds, and if both cottonseed cake and linseed cake are worth 1 cent a pound, find the price of cottonseed per ton at which the cost of linseed oil per pound is just twice that of crude cottonseed oil.
Ans., $9.157.

6. In a locomotive works building eight engines in a given month, the corresponding cost of production is $148,300. The locomotives weigh 80,000, 116,000, 180,000, 185,000, 210,000, 212,000, 220,000 and 280,000 lb., respectively. Find (a) the "cost per locomotive," using the number produced as the divisor; (b) the cost per 100 lb. of product; (c) the cost per ton of product; (d) the cost of each locomotive, based on item (b) and the weight of the locomotive.
Ans., (a) $18,537.50; (b) $10.00; (c) $200.00; (d) $8000, $11,600, $18,000, $18,500, $21,000, $21,200, $22,000, $28,000.—Total, $148,300.

7. In the case of the plant making motors and lamps, page 5, the costs of materials are: for motors, $700; for lamps, $180. Find the total costs (labor and materials) of one lamp and one motor.
Ans., motor $80; lamp $0.08.

8. The selling price of a standard automobile, at the factory door, is $1500. During a year, 1000 such machines are shipped at a freight cost of $30,000, the sum of distances transported being 360,000 miles. Using the arbitrary factor of *cost per machine per mile transported,* find the price to be charged a man 600 miles away for a machine to be delivered f.o.b. his own city.
Ans., $1550.

CHAPTER II

9. Assume, in the cases of the two power plants, page 8, that two types of plant are possible: one costing $100 and the other $200 per kilowatt capacity; and that operating costs corresponding are 3 cents and 2 cents per kilowatt-hour, respectively. If fixed charges may be taken at 15 per cent. of the first cost per year, find the total cost per kilowatt-hour for the high-priced and low-priced plants in each of the two kinds of service described.
Ans., 3.71 cents for the continuously running $100 plant; 3.42 cents for the continuously running $200 plant—note the *decrease;* 34.25 cents for the $100 reserve plant; 64.5 cents for the $200 reserve plant—note the *increase* in this case.

10. Group the following scattered items of cost in accordance with the chart on page 10, and state the value, the cost, the prime cost and the factory cost:

Superintendence	$160.05	General office expense	$ 87.80
Factory office expense	185.20	Pay roll	1015.45
Piece work labor	622.00	Salesmen's expense	64.30
Freight on raw material	22.50	Taxes	24.30
Freight on product	65.40	Power	415.30
Storeroom charges	945.80	Light	84.30
Laboratory expense	65.45	Depreciation	29.03
		Profit	410.04
	2066.40		2130.52

Ans., prime cost $2671.20; factory cost $3569.38; cost $3786.88; value $4196.92.

11. Take the following figures:

	Cost of fuel	Tons used	Product, lb.
January	$6500	1800	179,500
February	8500	2100	182,000
March	7200	1820	206,000
April	6600	1830	204,000

Find the price of fuel per ton, the consumption of fuel per pound of product, and the cost of fuel per pound of product, for each month. If these were the conditions in an actual plant, what further investigations would be warranted?

12. Suggest the general headings (not the specific items) for a classification of accounts in operating a power plant.

13. Reclassify the 39 accounts listed on pages 13 and 14 to correspond with the general plan of the chart on page 10. Suggest reasons why the new method of classification would be unsatisfactory.

14. Criticise the following methods of paying employees:
(a) By check, in small isolated communities.
(b) In cash, upon identification of the men.
(c) By check, in cities.

15. Suggest a cost divisor for (a) a school, (b) a department store.

CHAPTER III.

16. In a power plant, 9 lb. of steam are produced by the boilers for each pound of coal burned. Each pound of coal contains 14,000 heat units. Each pound of steam represents 1000 heat units. Of the total heat supplied by the fuel at the boiler, 20 per cent. goes up the stack, a portion appears in the steam, 2 per cent. is lost to the ash pit and the remainder is lost by radiation. Find the boiler efficiency and the number of heat units lost from each pound of coal by radiation.
Ans., efficiency = 64.3 per cent.; radiation loss, 1920 heat units.

17. In Exercise 16 the engines consume 30 lb. of steam per horse power per hour (2545 heat units = 1 h.p. hour). The steam expended in driving auxiliary machinery and lost in transmission is 10 per cent. of that received by the engines. The engines are direct-connected to electric generators, and the switchboard shows that 5/8 kilowatt of electrical output is obtained from each horse power at the engines. One kilowatt = 1.34 horse power. Find (a) the efficiency from steam to engine power, (b) the efficiency from engine power to switchboard, and (c) the efficiency from boiler outlet to engine throttle.
Ans., (a) 8.181 per cent., (b) 83.8 per cent., (c) 91 per cent.

18. In Exercises 16 and 17, make a list showing the disposition of the 14,000 heat units received in each pound of coal, giving percentages.

Ans.,

To stack, 2800 h. u. = 20 per cent.
To ash pit, 280 h. u. = 2 per cent.
Radiation at boilers, 1920 h. u. = 13.7 per cent.
Transmission and auxiliary loss, 810 h. u. = 5.79 per cent.
Loss between engine and switchboard, 112.2 h. u. = 0.80 per cent.
Loss at engine, 7497 h. u. = 53.56 per cent.
Useful work, 580.8 h. u. = 4.15 per cent.
Total, 14,000 h. u. = 100 per cent.

19. Compute the values of items (m) and (o), page 19, for Exercises 16 and 17.

Ans., 9 lb., 48 lb.

20. Draw off from statistical record No. 3, page 24, a statement like that of Record No. 2, page 22, for both mills A and B, for the operating costs of the fiscal year 1910–'11.

21. Divide each figure in statistical record No. 4, page 26, by 12; chart these records along with those for mill A in Exercise 20, and explain why the two graphs differ.

22. Prepare a statement like No. 4, page 26, for mill B, and chart the results in red ink on the diagram, page 25.

23. In the consumption totalization of page 26, the output for May is 1,150,000 kilowatt-hours and the coal consumption is 2,875,000 lb. Find the "coal per kilowatt-hour *to date*" for May, and compare this figure with the arithmetical average of the corresponding figures for the five months.

Ans., 3.01 lb.; arithmetical average, 3.916.

24. Prepare, from the data given in Record No. 2, page 22, a chart of the type first described under "Special Records," page 27.

25. An improvement expenditure of $100,000 has the following effect:

Months.	*Gross earnings.*
January	$110,000
February	111,000
March	113,000
April	114,300
May	115,800
June	117,200

Does the expenditure appear likely to "pay for itself" in 6 years?

CHAPTER IV

26. In a community of 100 men, raw materials are free and the value of commodities produced is distributed in equal shares. During the first year, the production is $100,000 and the wage per man $600. During the second year a profit-sharing system is introduced, so that each man is paid $900 and the total production is $175,000. Compare results as to wage rate, amount of labor per man and total wealth produced per man.

Ans., wage rate increases 50 per cent., production per man increases 75 per cent., exertion of each man presumably increases 75 per cent.

27. Under conditions like the preceding suppose the men to work fewer hours during the second year, to receive the same wages as during the first year, and to produce $100,000 at 50 per cent. greater speed than formerly. What results follow?
Ans., the total wealth produced will be unchanged, the wage per man will be unchanged, the hours of work per day will be reduced 43 per cent., the effort by each man, measured as the product of strength exerted and time, will be unchanged. The men are working 5.7 hours per day, rapidly, instead of 10 hours per day, slowly.

28. Assume the following data:

Workman's No.	*Shop Order No.*	*Charge.*
304	127,436	$31.19
302	127,436	11.22
308	127,436	19.47
306	127,436	12.24
307	127,436	18.11
309	127,436	36.60
320	210,421	7.65
323	209,640	6.40
325	227,044	7.35
360	300,001	4.50
361	309,090	6.65
382	411,212	5.35
304	485,840	5.20
309	490,601	5.95
309	512,311	3.20
307	584,390	6.05
320	590,090	.95
320	620,311	1.65
309	642,095	2.20
361	674,430	1.90
304	682,255	4.05

Make out the pay roll and prepare a statement of expenses like that on page 31.

29. Prepare copy for the printer for the shop orders, time cards and piece work slips necessary under the system described on page 31.

30. The day rate of $3.00 gives a production of 20 units per day. A piece work rate of 12 cents per unit leads to a production of 40 units per day. Find the effect on wages per piece, wages per hour (10 hour day) and total cost per piece (a) if fixed charges are 25 cents per day, (b) if fixed charges are $25 per day.

31. Revise the tabulation on page 37 on the following bases: (a) workman paid for 1/4 the time saved, (b) workman paid for 1/2 the time saved.

32. Answer Exercise 31 (a) for fixed charges 20 cents per day; (b) for fixed charges, $8.00 per day. What would be the strategic relation between (ratio of fixed charges to labor cost) and (proportion of time saved given the workman)?

33. Under the Rowan-Halsey plan, find the increase in hourly wage rate for each 10 per cent. reduction below standardized time in time consumed for an operation.

34. Tabulate the results of the differential piece rate under the conditions of page 38, if fixed charges are changed to 12 cents per day.

35. Check the statement made on page 38, "the total cost per bolt would be about 37 cents in either case."

36. Using the data on page 38, let the Taylor differential rates be 12 cents per bolt for a daily production of 20 or more, up to 40, above which the rate becomes 14 cents. Tabulate the results. Compare them with those in the text. How would they be modified if fixed charges were only 12 cents per day, instead of $12?

37. Under the Gannt bonus plan, page 40, let the day's production be standardized at 35 bolts. Other conditions being as in the text, tabulate the results and discuss the change from the workman's standpoint. If fixed charges have simultaneously increased to $6.00 per day, on what ground might the employer justify the change made in a standard day's work?

38. Consider the systems applied on gang work, page 41. What are their relative advantages and disadvantages?

39. Plot a new "efficiency curve" on the diagram, page 42, and tabulate the results under conditions otherwise resembling those of page 41.

40. Can any reasons be given for the special form chosen for the Emerson efficiency curve?

41. In the case of the Atchison shops, page 44, show that if by "output" is meant average value of output per man per day, and if by "cost" is meant average labor cost per man per unit of output, the three figures given are irreconcilable.

42. Compare the production per girl per hour, page 48, under the old and the new conditions. Suggest the corresponding probable variation in total cost of inspection.

43. From the Baldwin Locomotive Works tabulation, page 52, derive any statistical evidence of the superior position of apprentices in Class 3.

CHAPTER V

44. Find the cost of the following bill of material at a discount of 40, 10, 10, 5, per cent.:

500 ft. 1 in. bar at 20 cents per foot.
350 ft. 1 1/2 in. bar at 22 cents per foot.
675 ft. 2 in. bar at 29 cents per foot.

Ans., $172.10.

45. Prepare, for the printer, copy for the "requisition" form described on page 58.

46. Prepare the form "request for quotation" with card duplicate, described on page 58.

47. Interpret the ciphers K.SK, B.OK, SSK, the key-words being *black horse.*

48*a*. In an ordinary business what cipher characters will be oftenest used? Which ones may be most used in a department store?

48*b*. The following significances are surmised, in a price cipher:

$1.25=P.YM $9.98=U.UG $3.60=R.IN

Give the probable form for the complete key-word.

49. Prepare a form for "acknowledgment of quotation."

50. Prepare a form for a "purchasing order."

51. Write a form letter to a shipper urging haste in the delivery of materials due.

52. Devise a form for rubber stamp approval of invoices.

53. Interpret "2 per cent. 10 days; 30 days net."

54. Consider the following data and make specific recommendations as to further investigation:

Month	Fuel consumed, pounds	Cost of fuel	Product	Heat value of fuel, by laboratory test
January....	100,000	$200.00	500,000	10,000
February...	110,000	260.00	480,000	11,400
March......	100,000	245.00	495,000	11,330
April.......	105,000	204.00	511,000	9,980
May........	115,000	265.00	516,000	11,200

55. A man owns 20 per cent. of the $10,000,000 stock of a corporation which pays 5 per cent. dividends. He is also individually the proprietor of a plant which may sell its output to the former concern. Through some illicit arrangement he has the opportunity to make an individual profit of $100,000 at a loss to the former company just equal to this sum. Compare his interests as an individual and as a director of the $10,000,000 corporation.

Ans., he may gain $80,000 by sacrificing the corporation interest.

56. Prepare a form for a "stock card," as described on page 66, and show some typical entries thereon.

57. Prepare a form for a stores department daily report of goods received.

58. Prepare the "work order" and "stock order" printed forms described on page 67.

59. Give the essence of the results mentioned at the beginning of page 68, in a single percentage.

60. Subdivide items 7 and 8, page 70.

CHAPTER VI

61. Distinguish between "direct expense" (a part of "prime cost") and "direct factory expense." Give an example of each.

62. Take the following data:

Department	Output	Distributed direct cost	No. of men	Hours of time	Cost of labor
A.......	1000	$115	35	332	$103
B.......	1400	85	45	470	70
C........	600	620	160	1680	420
D.......	1100	40	12	84	23
E.......	1200	300	140	1000	200

If the undistributed "burden" expense is $1185, distribute this on the basis of the number of men employed and find the total cost per unit of output in each department.

63. Distribute the burden, in Exercise 62, in proportion to the "distributed direct cost," and tabulate the results.

64. Distribute the burden, in Exercise 62, in proportion to the "output," and tabulate results.

65. A linseed-oil mill produces 700,000 gal. of raw oil. Of this amount, 165,000 gal. are boiled. The direct costs are: raw oil, 55 cents; boiled oil, 56 cents per gallon. The burden cost applicable to oil production in general is $3500, the additional burden applicable to boiling oil is $675. Find the total cost and the cost per gallon of each kind of oil: (a) as computed on page 74; (b) by distributing the general burden in proportion to *quantity* rather than to *cost.* Which of the methods, (a) and (b), is to be preferred?

Ans., (a) raw, 55.6 cents; boiled, 56.9 cents; (b) 55 1/2 cents for raw, 56.91 cents for boiled.

66. In Exercise 62, distribute the burden in proportion to the hours of time, and tabulate the results.

67. In Exercise 62, distribute the burden in proportion to the cost of labor. Tabulate the results.

68. Find, from Exercise 62, the cost of material, the average wage per hour, and the average daily wage per man, in each of the five departments.

69. A plant contains seven machines, giving the following data:

	1	2	3	4	5	6	7
Hours run......................	250	218	200	30	204	170	185
Horse-power hours consumed......	1000	1090	4000	900	408	510	925

Find the average load in horse power on each machine.

70. In a given month, the total power developed costs $358. The machines in Exercise 69 run the following numbers of hours:

Machine................	1	2	3	4	5	6	7
Hours..................	250	200	50	33 1/3	500	333 1/3	200

Find the power charge against each machine; how much is the power charge, for each of the machines, per hour run?

71. $500 rent is paid monthly for a plant in which 50 men are employed 10 hours daily, 300 days per year, at 20 cents per hour. What burden per hour does the distributed rental expense add to each man's wage?

72. Take the following data:

Direct labor, 100,000 hours.	$20,000
Materials	60,000
Direct expense	2000
Wasted time	1600
Heat	400
Light	620
Foremen and supervisors	1125
Employers' liability insurance	320
Power	1158
Repairs and replacements	1050
Repair supervision	300
Fire insurance, other than on buildings	$ 160
Factory indirect expenses	1650
Selling expense	675
Administrative expense	900
Spoiled work	130
Standard patterns, etc	600
Rent	1250
Taxes	115
Depreciation	600
Fire insurance on buildings	75
Non-productive labor	390

It is agreed that the indirect expenses chargeable against productive machine time shall be distributed in proportion to the horse-power *loads* thereon, as from Exercise 69. *Rent* and *taxes* are to be charged half against labor time, half against machine time. The same remark applies to *depreciation* and *insurance on buildings*. *Non-productive labor* is divided equally against machine time and corrected prime cost. The fourth group of expenses is charged against corrected prime cost, following the tabulation on page 80.

What, in accordance with this tabulation, are the elements in the total cost of an item of product on which the labor cost (100 hours) was $22.00, the material cost $38.00, and the direct expense $1.65, if machine No. 3 (only), Exercise 69, was used 7 hours in producing it?

CHAPTER VII

73. The cost of a plant is $40,000. It depreciates by $3000 each year. The apparent profits in 10 years are $22,000, no allowance being made for depreciation. What are the real profits in 10 years?
Ans., *loss* is $8000.

74. If in Exercise 73 no change has occurred in other assets than *plant*, and if the $22,000 profits have been distributed to the owners, compare the net assets at the beginning and end of the ten year period.
Ans., have *decreased* $30,000.

75. Take the following data:

Years	Gross earnings	Operating expenses and fixed charges
1900	$60,000	$40,000
1901	82,000	55,000
1902	75,000	38,000
1903	77,000	53,000
1904	65,000	54,000

The last column does not include depreciation. The capital stock is $200,000. Tabulate the dividends, depreciation and surplus under the conditions (a) 10 per cent. dividend on stock followed by $4000 depreciation charge when possible or by as great a charge as is possible, less than this amount; (b) $4000 depreciation charge, $4000 surplus, balance as dividend.

76. Compare the probable lives of (a) a masonry dam, (b) a wireless telegraphic outfit, (c) an automobile, (d) a brick dwelling house.

77. In Exercise 75, an engine costing $100,000 is bought in 1900. Distribute this cost over the five years in such proportions as to make the net earnings constant.

78. Compare interest rates in the Klondike, New York and Berlin. What effect have these differences on depreciation charges?

79. A plant depreciates by $200,000. Meanwhile, it has been extended to the value of $200,000 by improvement expenditures. No depreciation charge has been made. Improvement expenditures have been treated as operating expense. By what amount has the value of the plant changed? By what amount do the books show it to have changed?

80. A machine worth $10,000 has a 30-year life and a 4 per cent. residual value. With interest at 4 1/2 per cent., what should be the annual allowance for depreciation?
Ans., $157.44.

81. If the life of an $8200 machine is 11 years, and its negative residual value is $500, what is the annual allowance for depreciation with interest at 6 per cent.?
Ans., $581.16.

82. How does the value of the fundamental ratio described on page 8 affect the ratio of depreciation to gross earnings? In what sort of industry is close attention to depreciation charges relatively unimportant?

83. Suppose the machine in Exercise 80 to be in good condition after the expiration of the 30-year period and to keep operating for 8 years more. How much money will accrue, during the 8 years, in its depreciation reserve fund and what use may be made of this money?
Ans., accumulations will be $4052.16.

84. Find by logarithms the value of A for the revised interest rate, page 96.
Ans., $6.90.

85. In Exercise 84, suppose that after 5 years the estimated life as well as the interest rate is revised, and that it is assumed that the machine will last only 3 years more; what is the value of A in this case?
Ans., $12.10.

86. In Exercise 80, the machine is ultimately replaced by a better one costing $18,000. What will be the sources of this $18,000?

87. If the tabular figures on page 98 are fairly comparable with the statement regarding street railway companies at the top of page 87, is the management generally conservative?

88. Make all the ledger entries necessary to describe the transactions in Exercise 80 and Exercise 86.

CHAPTER VIII

89. Should the following expenditures be classed as "operating cost" or as "betterments"? (a) Rebracing an old boiler to fit it for carrying higher pressure, (b) retubing a boiler, (c) boring an engine cylinder, (d) replacing common cheap asbestos cocks by high grade expensive blow-off valves, (e) mechanical draft equipment in an existing power plant, (f) stoker appliances in an existing power plant.

90. An improvement costing $10,000 is applied to a plant worth $100,000. If fixed charges are 15 per cent. on the investment and the improvement causes a saving of 5 per cent. on an annual output of $200,000, what is the net percentage return on the improvement investment? If the annual output of the plant is $35,000, other conditions being the same, what result follows?

Ans., net returns are 85 per cent. and 2 1/2 per cent., respectively.

91. Which is preferable: the expenditure of $50,000 on a plant producing $200,000 yearly, for the purpose of increasing output 20 per cent. when the profits are uniformly 25 per cent. of the output value; or the expenditure of the same sum for producing a saving of 5 per cent. on the annual output?

Ans., the gross return either way is $10,000 annually.

92. An opportunity exists for a saving of $1000 per month by the expenditure of $4500, this saving being immediately attainable. By deferring expenditure for 6 months and increasing it to $6500, the saving may be increased to $1100 monthly. If the total fixed charges on either improvement expenditure are 30 per cent. annually, and both machines are expected to last 4 years, which should be installed? What will be the loss if the wrong expenditure is made?

Ans., the lives of the machines may be ignored, because "total fixed charges" include depreciation. Unless the $6500 machine is installed there will be a loss of $2400.

93. What is the ratio of fixed charges per unit of output, in 10-hour day service, to that in 24-hour day service, if the average hourly production under the latter plan is 0.9 that under the former plan?

Ans., 2.16.

94. What is the ratio of labor cost per unit of output, in 8-hour day service, to that in 12-hour day service, if the workman's wage per hour is 25 per cent. greater in the former case, and his output per hour is 20 per cent. greater?

Ans., 1.04.

Compare (a) the number of men employed, total output being fixed, and (b) the average daily wage.

Ans., (a) *inc.* 25 per cent.; (b) 16 2/3 per cent. dec.

95. A corporation starts in business with an insurance fund of $1,000,000, which is regarded as ample. The value of the insurable property does not change, and the insurance fund bears 5 per cent. interest. What shall be done with the earnings of this fund?

96. If in the example at the end of page 107 (footnote), the insurance policy was for $10,000, what percentage gross gain resulted from the $500 expenditure for improvement?

Ans., 50.8 per cent.

97. Buildings are insured for $6500, stock for $9500, both at full cash value and at a rate of 85 cents. A fire, after premiums have been paid for 8 years, causes a building loss of $3900. What amount of insurance could be collected under the "contribution clause"?

Ans., $1980.

98. A plant in process of erection represents the contractor's expenditure of $80,000, on which the owner has made payments of $60,000, in strict accordance with the contract terms. The contractor pays insurance premiums on a policy amounting to 80 per cent. of the value of work in progress. A total loss occurs. State all the transactions involved in a settlement. How much does each party lose, if the aggregate of premiums paid is $500?

99. A partnership has assets of $100,000, and owes $60,000, exclusive of loans from the three partners amounting to $2500, $6500 and $1000, respectively. The capital put in by the three partners was $5000 for each. Earnings are divided in the proportions, 42/100, 36/100, 22/100. State the distribution of assets upon termination of the partnership.

Ans., partners get $13,800, 16,900 and $9300, respectively.

100. In organizing a corporation, a number of individuals contribute $400,000 in return for $4500 shares (par $100) of stock. The balance of the capital stock, 5500 shares, is floated at 90 less a brokerage commission of $160,000. The sum of $65,000 is expended in preliminary expenses. What, then, are the total real assets of the company? What proportion of its capitalization may be regarded as "water"?

Ans., (a) $670,000; (b) $330,000 = 33 per cent.

101. Are the following things patentable? A roulette wheel; a steam turbine direct-connected to an air-compressor; a rotary engine of the type invented by Hero of Alexandria: a rug?

102. A trust is formed, which absorbs 22 mills having aggregate physical assets of $19,000,000. The capital stock issued is $50,000,000. What items may be suggested as offsetting the apparent deficit of $31,000,000?

103. A railroad whose stock has a par value of $50 issues a 15 per cent. stock allotment at par when its stock is selling at 165 1/2 per cent. What are the rights worth, per share of old stock? How does the new stock issue affect the surplus of the company?

Ans., value of rights is $4.91 1/4.

104. On the general principles suggested by the *diagrams* of pages 121, 122 and 123, prepare a chart of the *tabulated* organizations on pages 121 and 124.

105. Compare the salary costs under the two plans of page 123.

106. Prepare a chart for a combined line and staff organization in a large engineering works, giving suggestive titles to the various officials.

107. On an article which sells at retail for $100, the retailer expects a profit of 40 per cent., the wholesaler of 10 per cent. What are the prices to be charged by the manufacturer to the wholesaler and by the latter to the retailer?

108. Consider two mines, *a* and *b*. The former has a concentrator, *c*, immediately adjacent, which reduces the weight of materials by two-thirds. There are two smelters, *d* and *e*, in which the working costs are respectively 4 and 5 cents per 100 lb. of material received. The working cost in *c* is 1/2 cent per 100 lb. of raw material. Freight from *c* to *d* is 9 cents; from *a* to *d* is 9 cents; from *a* to *e* is 3 1/2 cents; from *b* to *e* is 2 cents; from *c* to *e* is 3 1/2 cents; from *b* to *d* is 2 3/4 cents, all per 100 lb. Assume that mine *a* brings its product to the concentrator at a cost of 32 cents per 100 lb.; that mine *b* can put its product on cars at 29 1/2 cents per 100 lb. Smelter *d* obtains 13 1/2 cents per pound, less freight of 19 cents per 100 lb., for the final product which it produces (15 lb. per 100 of raw material from concentrator, 5 1/2 lb. per 100 of raw material from mines). Smelter *e* similarly obtains 13 3/4 cents, less freight of 7 cents, with productions of 15 1/2 and 5 3/4 lb., respectively. Smelter by-products are valueless. Find the profits per 100 lb. of material brought out of each of the mines, under each of the six conditions possible.

109. Make a chart of the organization tabulated on page 130.

CHAPTER IX

110. What classes of entries are included in the following accounts: Office fixtures, stable expense, interest, royalties, allowances to customers?

111. To what accounts should entries be made for the following: A sale of stable manure; a charitable contribution; insurance paid in advance?

112. Are balances, in Exercise 110, resources or losses, liabilities or gains?

113. What would be the objections to the practice of never taking an inventory?

114. At the beginning of the fiscal year a business presents, after closing the books, the following balance sheet:

	Dr.	*Cr.*
John Smith, owner..........		$2500
Thomas Brown, owner......		2750
Real estate.................	$2200	
Office furniture and fixtures.	1600	
Bills receivable.............	1200	
Bills payable...............		2200
Merchandise...............	2500	
Cash......................	400	
Royalties accrued...........		450
	7900	7900

Make ledger entries for the following:

(a) Owners buy merchandise from J. Jones for $1600, paying cash $200 and note $1400.

(b) Salaries aggregating $1100 are paid in cash.

(c) Merchandise aggregating $2250 is sold for cash.
(d) Office expense $100 is paid in cash.
(e) A loan of $500 is obtained from the bank, a note being given.
(f) The note under (a) is paid, with interest for 6 months at 5 per cent.
(g) Bills receivable from last year's balance are paid in cash, less a bad debt of $200, plus interest of $160.
(h) Bills payable under last year's balance are paid, with interest amounting to $30.50, in cash.
(i) Accrued royalties under last year's balance are paid in cash.

115. In Exercise 114, inventory shows merchandise to be worth $2260, office furniture and fixtures $1500. Other assets (except *bills payable* and *cash*) are as before. Interest accrued under the bank note (e) amounts to $22.00. Make the closing entries and prepare the balance sheet, crediting net profits to the owners of the business in equal shares.

116. In Exercise 115, what is the value of the "quick assets?"

117. Check the statement on pages 144, 145.

118. Compute the gross earnings per mile, for each year from 1896 to 1905, page 145. Compute the average for this period.

119. Check the tables on pages 146 and 147, as far as is possible.

CHAPTER X

120. Show how the seven building widths mentioned on page 155 may be obtained while using only the two standard spans.

121. Freight on oil in 10,000 gallon tanks from Buffalo to Boston is 2 cents per gallon. In barrels (holding 50 gallons) it is $1.75 per barrel. It costs $1.45 per barrel to put oil in barrels at Buffalo, $1.05 to do this in Boston. There is no leakage on tank car shipments; the average loss to the shipper by leakage, on barrel shipments, is 1 per cent. What is the gross gain per 10,000 gallons, by shipping oil in tanks from Buffalo and barrelling it in Boston? What factors must be considered as operating against this gain?

122. Suggest a grouping of buildings, on a square plot, across which a canal runs diagonally, for a locomotive works including foundry, forge shop, pattern shop, pattern storage, power plant, boiler shop, machine shop, paint shop, carpenter shop, erecting shop, storehouse and offices.

123. Write a letter accepting a contractor's bid for doing certain work according to plans and specifications submitted and appointing a day for the execution of contract.

124. In Exercise 123, what objection may be made to the following clause in such a letter: "We are prepared to accept your proposal providing you can furnish satisfactory sureties."

125. Suppose, in Exercise 98, the contractor has allowed his insurance premium payments to lapse. What is the obligation of his surety?

126. On pages 170, 171, which of items A to Q would be found by inventory of the physical property?

127. In the Worcester case, pages 171, 172, state in dollars the contentions of both parties and the decision of the court. Who won?

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