



Increased productivity through incentive management and industrial engineering
by Maurice W Burke

A THESIS Submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree
of Master of Science in Industrial Engineering
Montana State University
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Abstract:

The prime objective of this thesis is to show that increased productivity, of a lasting nature, may be obtained through "Incentive Management," founded on the basic concepts of industrial engineering. Unless so founded, its application in industry will be accompanied by all the classical disadvantages of the "trial and error method." The "trial and error method" is effective in only a fraction of the attempted installations, usually on a short-term basis, accompanied by a need for frequent revision. This results in serious damage to the productivity of the labor force in a given plant.

The secondary objective of this investigation is to demonstrate why the pertinent techniques of industrial engineering must be applied to the solution of the general problem of designing an "Incentive Management System." The procedure or method of investigation used was of a threefold nature: (a) a review of literature was made, (b) a survey was conducted of the practices of industrial organizations, labor unions and trade associations with experience in the field of "Incentive Management, (c) the writer's experience as an industrial engineer was utilized to supplement the material gathered, Data thus gathered were analyzed and the resulting elements were employed to construct a generalized method of approach for establishment of a procedure for design of an "Incentive Management System" Therefore, this thesis has attempted to outline the first two steps of a four step solution to the problem of increasing overall productivity of an industrial enterprise through "Incentive Managamnt." These four steps being: 1. Investigation and analysis.

2. Establishment of a generalized method.

3. Establishment of the detailed procedure for the design of an "Incentive Management System." 4. Design and application of an "Incentive Management System" in an industrial enterprise.

Parts 3 and 4 would require adaptation of "Incentive Management" to the requirements and limitations of a given unit in a particular industry. This was not attempted, as being beyond the scope of the present study.

The conclusion is that a "rational" design procedure can be created for each specialized industrial situation In which an "Incentive Management System" can be employed to increase productivity.

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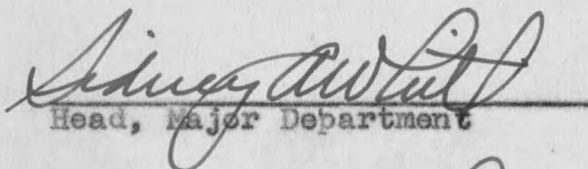
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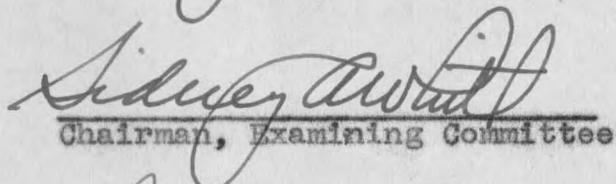
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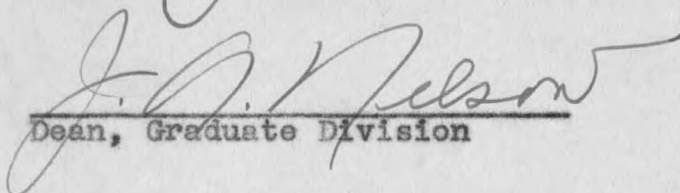
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Abstract

The prime objective of this thesis is to show that increased productivity, of a lasting nature, may be obtained through "Incentive Management," founded on the basic concepts of industrial engineering. Unless so founded, its application in industry will be accompanied by all the classical disadvantages of the "trial and error method." The "trial and error method" is effective in only a fraction of the attempted installations, usually on a short-term basis, accompanied by a need for frequent revision. This results in serious damage to the productivity of the labor force in a given plant.

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Data thus gathered were analyzed and the resulting elements were employed to construct a generalized method of approach for establishment of a procedure for design of an "Incentive Management System."

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The conclusion is that a "rational" design procedure can be created for each specialized industrial situation in which an "Incentive Management System" can be employed to increase productivity.

Chapter I

INTRODUCTION

INCENTIVES AS A TOOL IN INDUSTRIAL MANAGEMENT

The private enterprise system, such as represents the bulk of economic endeavor in the United States, rests on a foundation of private ownership of Industry. This system necessarily requires the investment of private resources, chiefly savings from income beyond current needs. The required investment will take place only if Industry assumes certain responsibilities to the investor. Foremost is that of supplying the economic incentive in the form of a reasonably adequate and secure return on the investment. This is true whether the enterprise is a single proprietorship, a partnership, or a large corporation. If this were not true, the public would have no desire to invest any wealth in Industry because of the risk involved.

However, it has in recent years become increasingly obvious that in the long range attainment of the profit objective Industry must also meet certain responsibilities to other interested parties. These additional responsibilities are to the public at large, the employees, and the consumers. These groups depend upon and are therefore vitally interested in the efficiency of the production process. Among many things these groups are interested in adequate volume,

constant quality, low costs, maximum quantity or productivity per unit of investment, lower sales prices, greater real income and wages, and maximum employment. Industry's problem is to meet these responsibilities. How is this to be accomplished when the public and consumer are clamoring for a larger volume of product at a lower price, while the employees are asking for an increase in real wages and the investors for an increased return on investment. To answer this problem management has naturally turned toward more efficient utilization of all factors of production including it's investment in plant and equipment. This necessarily means that the labor force must also be utilized as efficiently as possible. This would minimize the labor cost per unit of production. Since the machines and equipment in the factories are controlled by the employees, an increase in productivity on the part of the employees will result directly and indirectly in an increased productivity per dollar of investment.

It may be said that management has always recognized the more or less obvious necessity of obtaining a maximum of productivity from the labor force. Since Taylor's early work it was generally realized that the labor force as a whole does not maintain a rate of production near its capacity,

under the usual circumstances. By capacity, I mean the production that may be maintained by a worker without danger to himself, to his equipment or his fellow workers. This presence of under-capacity workmanship has been effectively proven many times during the last 50 years. Taylor, (1911) in his experiments at the Bethlehem Steel Company, increased the average productivity of the pig iron gang from 12½ long tons per man per day to 47 long tons. This was not due entirely to the increased efforts of the workmen involved but was also due to the application of the "Principles of Scientific Management" to the work under consideration. Taylor (1911) lists these principles as follows: first, the development of a science to replace the old rule-of-thumb knowledge of the workman; second, the scientific selection and progressive development of the workman; third, the bringing together of the science and scientifically selected and trained workman; fourth, proper division of the work between the worker and management.¹ The results achieved by Taylor showed what could be accomplished in the way of increased productivity. Taylor saw that management could become more of a science, and not merely an individual art, and through logical processes unite high wages with low labor cost.

1. Taylor, F. W. 1911. SCIENTIFIC MANAGEMENT.
p. 36, Harper and Bros., New York.

This was to be achieved by:

1. Assigning clearly defined tasks.
2. Maintaining standard conditions.
3. High pay proportional to success.
4. Loss of pay in case of failure.
5. Making task so difficult it could be accomplished only by a first-class man.

It is the last condition that has been adopted by Industry, although in a considerably modified form, and is the basis for an incentive system. Taylor (1911) had a sociological concept that only first-class workmen should receive incentive wages. Modern wage incentive systems are so designed that the "normal worker" may earn incentive payments either by working at a "normal pace" or by exceeding his normal capacity. However, there is still an upper limit on the earnings as advocated by Taylor. That limit of maximum earnings is due to the inherent capacity of the worker. Taylor's system provided no incentive for the "less-than-first-class-worker." Modern incentive plans call for increased payment for all workers after achieving the "task," which is usually the output achieved by a "normal worker" working at a "normal pace" although it may vary with the individual plants. The difference between the two concepts is simply the difference between basing incentive on the "quickest time possible" or basing it on the time required by a "normal operator" working at a "normal speed." This concept of normal is usually obtained by a somewhat subjective

process of "speed and effort rating" as applied by the individual Time Study Engineer who sets the time standard.

It has been verified often by representatives of labor that incentives could result in an increase in worker application as high as fifty per cent. Mr. Solomon Barkin (1951), research director for the Textile Workers Union, CIO, substantiated this in a recent article by stating that this would be true of the usual wage incentive plan.¹ We may conclude from such figures that if the "incentive spread" or increased exertion over that of a normal operator is approximately 20% to 30%, then the worker has been working at an average minimum of 20% to 30% less than normal. If this situation is considered to be typical of contemporary Industry, then there remains considerable room for improvement in the productivity rate of the individual employee while maintaining the same fixed investment in plant and equipment. It is obvious, of course, that any means which would be taken to increase the worker's productivity would also result in some increase in other variable factory costs regardless of the circumstances. This would be due primarily to increases in the supervisory force, industrial engineering personnel, accounting costs, and wage administration costs. One of the purposes of this thesis is to demonstrate

1. Barkin, S. 1951. MANAGERIAL ATTITUDE TOWARD WAGE INCENTIVE SYSTEMS. Ind. & Lab. Rel. Rev. Vol V, No 1, p. 96.

that the increase in other variable factory cost should be less than the decrease in direct labor costs. Many firms still have a notion that any decrease in the above mentioned labor costs will somehow, naturally result in an overall decrease in product costs. They do not recognize that there is an optimum point in almost every case where the additional variable factory costs will become equal to or will exceed the savings due to the institution of a given incentive plan. In the following figures there are illustrated a few of the basic relationships that may exist under various plans whose object is to increase productivity and lower operating costs.

An analysis of Figure 1 reveals the relationships that exist between productivity and plant capacity. For purposes of this illustration it is assumed that a plant is operating at 100% capacity. Due to sales demands, an increase in production is required. Production may be increased only through increased productivity of the present fixed assets or by additional investment in plant and equipment. However, the firm does not have available sufficient funds to invest in the necessary expansion program. Management has elected to use whatever means available and at its disposal to increase the productivity of their present investment. (An explanation of the symbols used will be found in the Appendix.) At this point a greater than proportional

increase in variable costs is required to increase the productivity. Assuming fixed charges are to remain constant, variable costs must rise if the increased production is anything but voluntary. Whether this is accomplished through increased supervision, better supervision, or incentives is immaterial. Nevertheless, at 100% capacity additional variable costs are required to obtain the increased productivity. With the new variable costs, beyond 100% current capacity, we have a new curve showing the total costs under the new set of conditions. The difference between this curve and the net sales is obviously the net profit from operations. In analyzing this difference we find that at 100% capacity we have decreased the net profit that may be obtained. However, as production is expanded due to the additional productivity, the net profit increases until we reach a point at approximately 120% of plant capacity. In this instance it is the point of maximum return. If we continue along the curve, we find that at 130% the net profit has fallen to approximately that obtained at 100% capacity under the old circumstances. Ordinarily this will be at peak production. Management will produce to this point to satisfy sales demands and meet deliveries by competitors, but will ordinarily be unwilling to reduce the net profit that goes with further increases in production, assuming any further increase to be

possible. Thus, there can be a point on the curve below the maximum practicable capacity (e.g. at 120% of capacity) at which the returns are maximized.

In Figure 2, we find a chart similar to that in Figure 1 with somewhat different assumptions. This chart shows the relationships existing when labor productivity may be increased immediately beyond zero output with resulting savings produced above zero output. The variable costs are less in this instance than under the conditions assumed in Figure 1. This would represent the conditions existing under an incentive plan designed to increase the workers earnings per unit of output as compared with a straight hourly pay. The variable costs under the original conditions are represented by V'_{100} . We have again represented 100% capacity as the maximum obtainable under the old conditions without incentives. V''_{100} is the variable cost under the new plan at 100% capacity. In this particular case it is less than the previous figure. This would mean that management is sharing the results of the increased production and all does not go to the worker. At nearly 160% of plant capacity we again find the net profit decreasing at an exceedingly fast rate.

It is evident from these two curves that there can be an optimum point under many conditions which it is economically

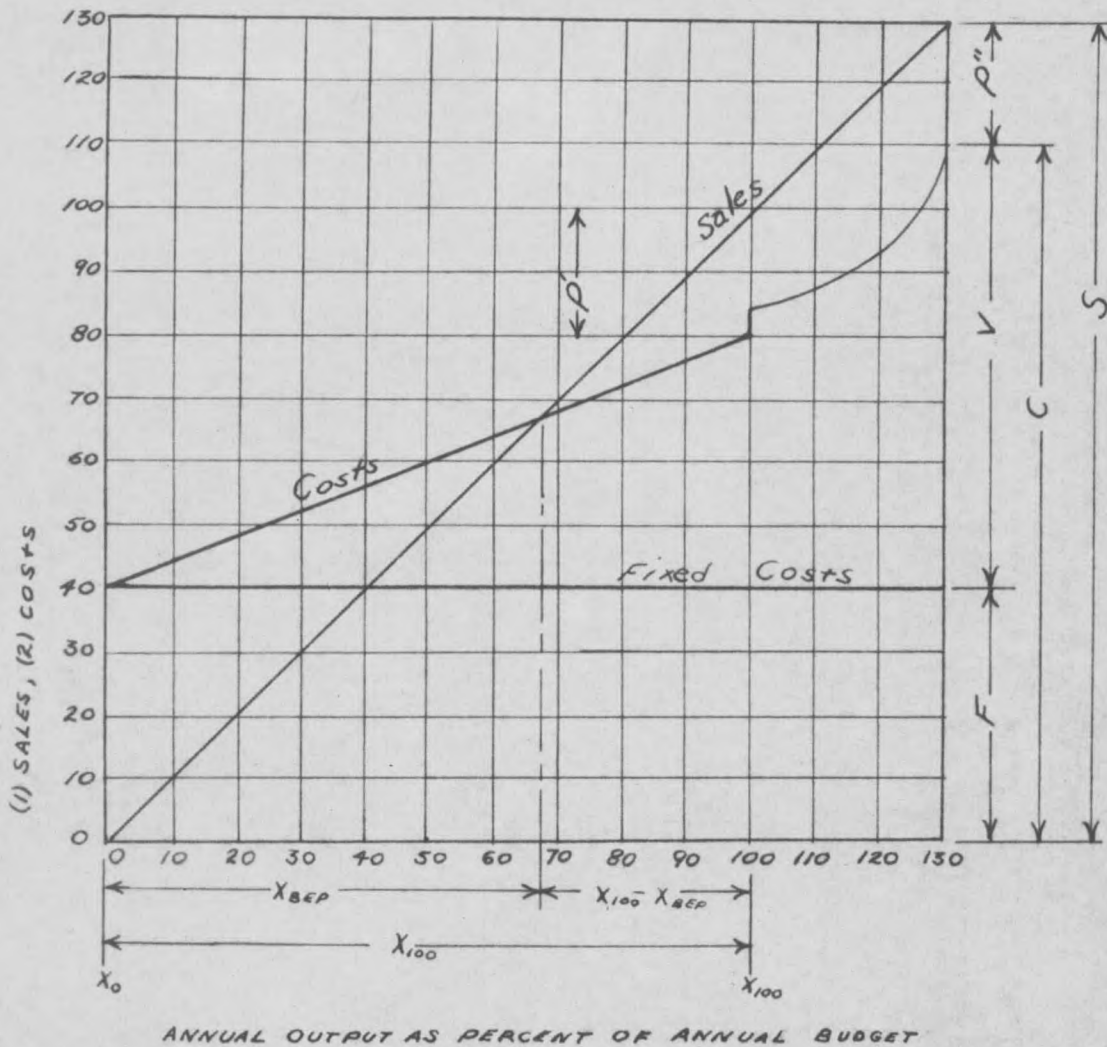


Figure 1
Operating Characteristics of a Manufacturing Enterprise
Depicting Relationships Existing Between
(1) Net annual sales, i.e. gross annual receipts in % of annual budget, and
(2) Costs as % of net annual sales, vs. the annual output or sales as a % of the annual budget.

(1) SALES, (2) COSTS

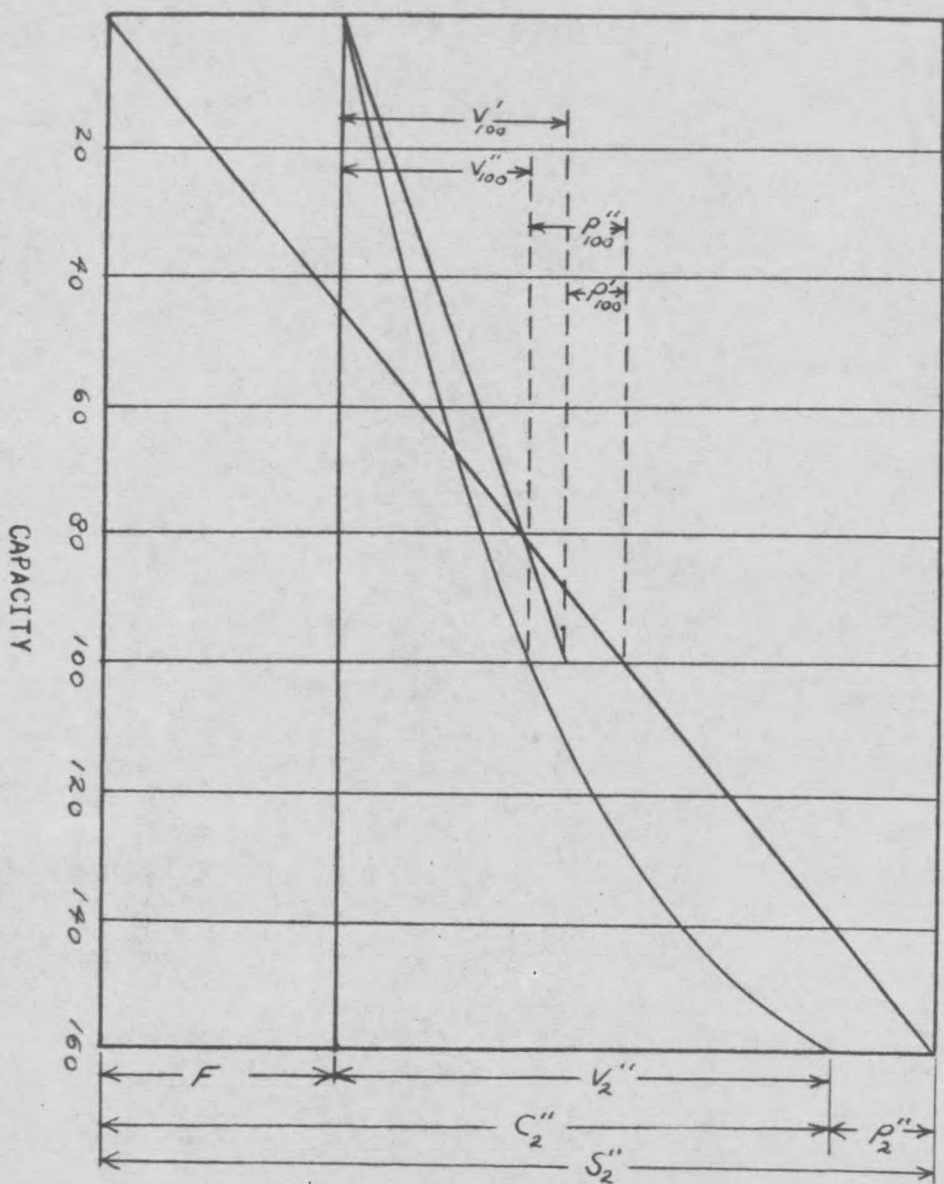


Figure 2
Operating Characteristics of a Manufacturing Enterprise

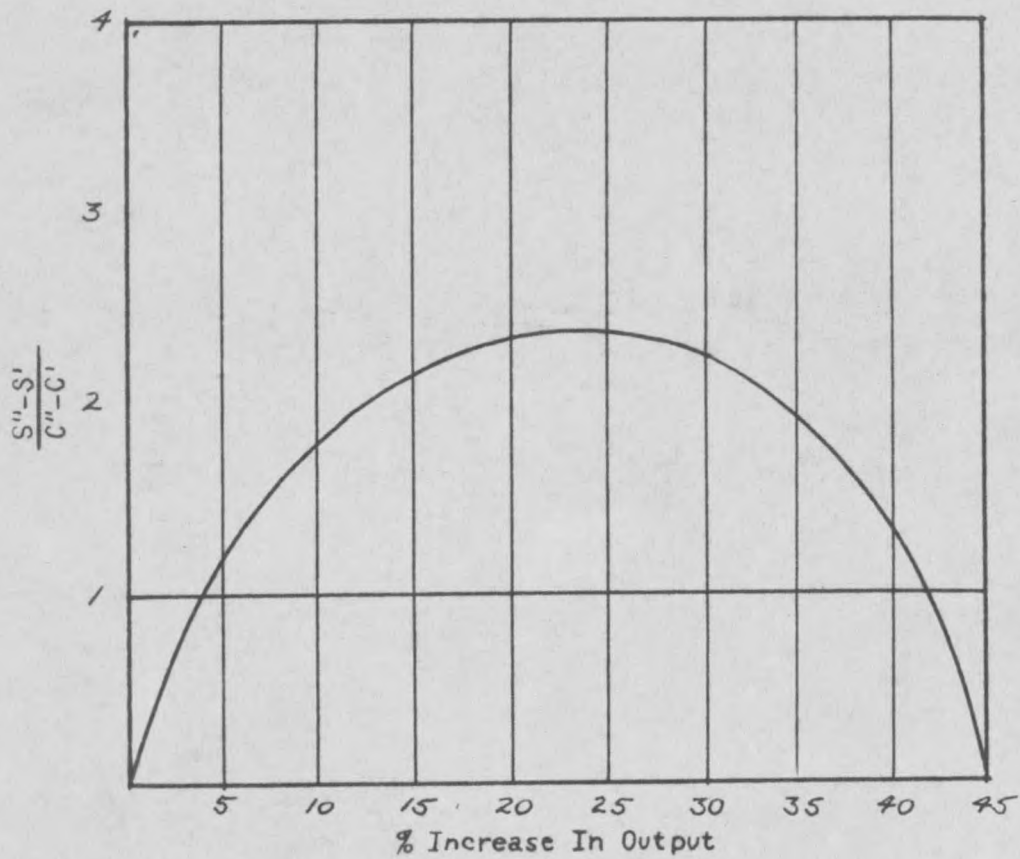


Figure 3
Operating Characteristics of a Manufacturing Enterprise

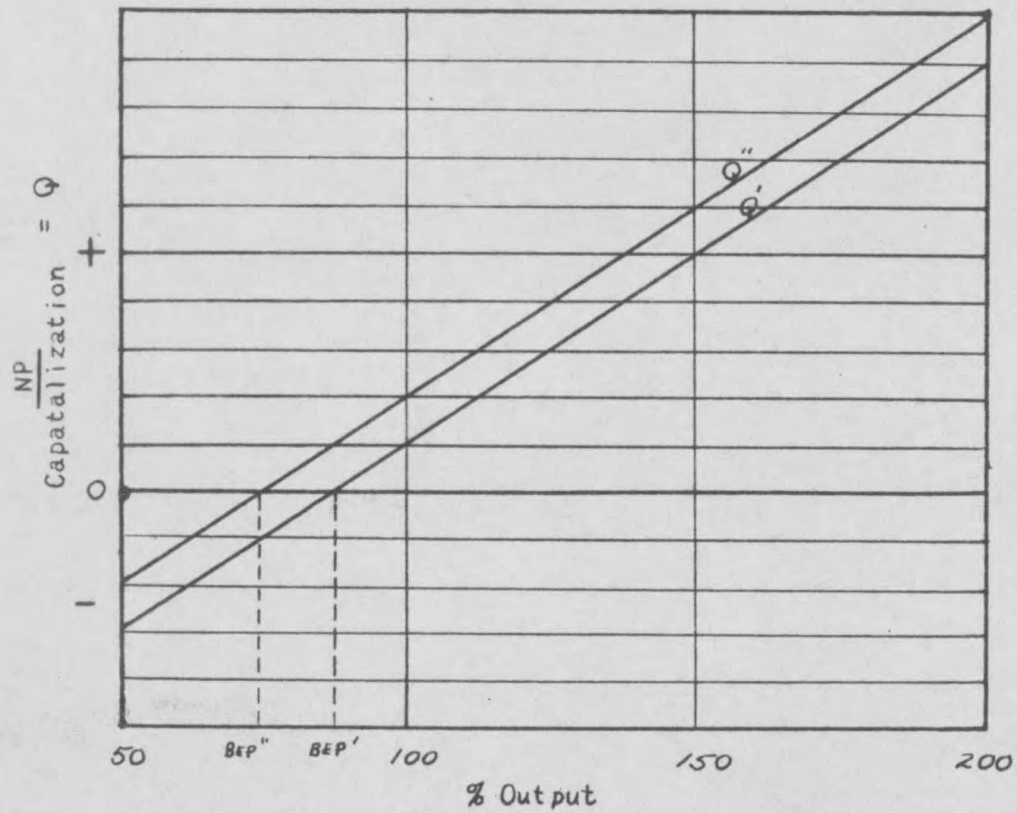


Figure 4
Operating Characteristics of a Manufacturing Enterprise

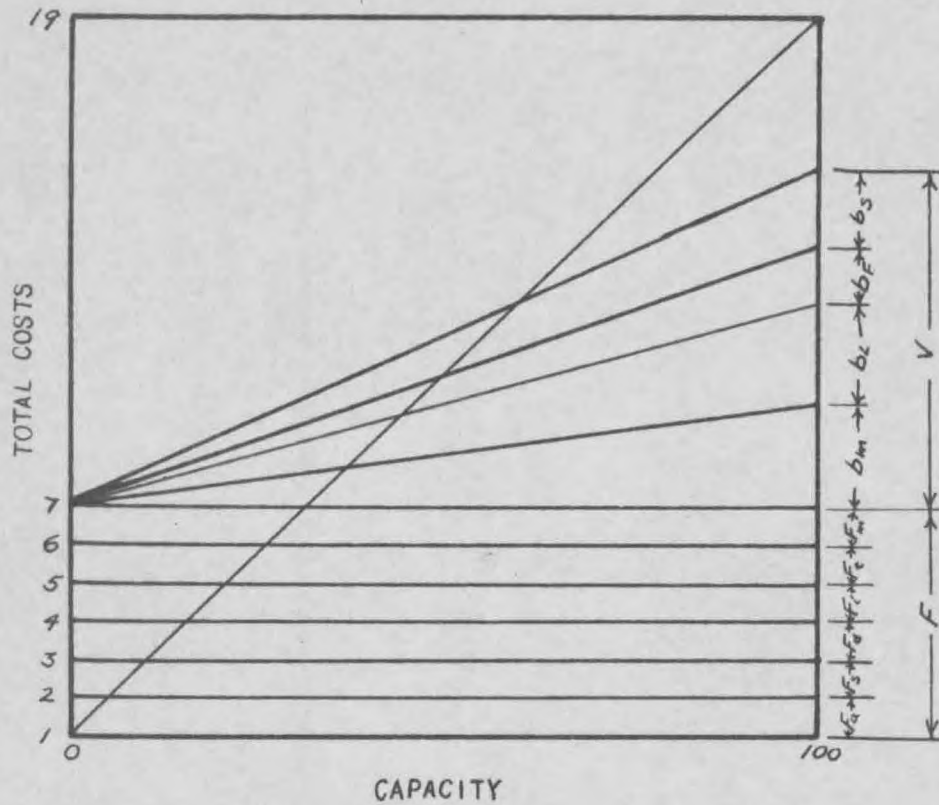


Figure 5

Cost Components of a Manufacturing Enterprise

inadvisable to exceed. This will not be the relationship necessarily existing under all circumstances of plant design, but serves to warn us of the pitfalls arising from unverified assumptions. This is further demonstrated by Figure 3. Figure 3 shows the relationship of an increase in sales income to an increase in variable costs resulting from increased productivity assuming another set of industrial circumstances. Under these assumptions, we begin at some maximum previous output and show how the increase in sales can cause the income increment versus costs ratio increment to rise to a maximum and then descend to where the firm is operating under conditions as unfavorable as those previously existing.

The figures are presented to graphically emphasize the fact that increased productivity by the direct labor will not necessarily mean either increased profits or decreased costs at all levels of plant output. Each company must analyze the circumstances under which its plant will be operating before it can determine the profitableness of increased output. The method used to obtain the increased productivity necessarily determines the shape of the cost curve and the resulting relationships between total costs, gross sales income, and plant capacity. The management must determine after an analysis of all available data the added costs

it will be willing to bear and the profits it expects to receive from increased productivity. If the firm is properly organized and managed and the incentive system is properly designed, the result could readily be similar to that appearing in Figure 4. The relationship shown here exists when increased productivity is achieved by two separate methods, both of which are increasingly profitable up to maximum capacity. Q'' accomplishes its result through financial incentives, Q' through investment in equipment and machinery with additional capitalization. The advantage of Q'' over Q' is the increased return on investment or decreased loss for any given plant capacity for a varying capitalization and investment. This is also accompanied by a reduced break-even point on the operations. (The term break-even point is used as explained in the Appendix.) It is exceedingly useful in determining company policies in regards to additional fixed investment (which raises the BEP, usually) or the effect of unavoidable reduction in sales volume on profitableness of operations. It can likewise be used to show the effect of installing an incentive system in a plant. It is defined as the point below which sales may not fall, assuming otherwise constant economic conditions, if the firm is to operate without a loss.

In determining the type of incentive system to be adopted

for a particular industrial enterprise, the relationship between fixed costs and total costs is paramount. As fixed costs become a larger share of total costs, efforts must be directed toward utilizing the fixed assets from which many of the fixed costs arise as effectively as possible. (A high percentage of fixed costs normally means a higher break-even point. This may require the use of incentives to spread fixed costs over more units of production at an increase possibly in direct labor costs.) Thus, if we increase production by, say, 30% with less than a directly proportional increase in direct labor unit costs, we may achieve a desirable effect upon the break-even point. The key lies in the relationship between the total costs curve and the sales income curve. Thus, the overall relationships are more important than any individual cost increases or decreases.

In analyzing the causes and characteristics of the total cost curve, Figure 5 is useful in that it shows at a glance the components of the total cost curve. The variable costs are particularly important because their flexibility makes them readily susceptible to measures taken to reduce costs. By varying one or all of the variable components we may affect the total cost curve and consequently the net profit on operations. It is important to note that by increasing the variable overhead component a small amount it may be

possible to decrease the direct labor or the materials components by more than a directly proportional amount. This is especially true when additional engineering personnel are added by the organization. Engineering is commonly responsible for reducing material cost. Through industrial engineering we may also reduce the direct labor costs and production costs considerably. This may also be accomplished through functional redesign of the product.

Because of the complexity of modern industrial establishments, management should accept the responsibility to encourage or assist employees to raise their level of productivity to its proper place. This increased productivity to be lasting should be accompanied by higher real wages for the employee, lower operating costs, increased sales through reduced sales prices, and more income for the investors.

It is obvious that production costs could be considerably lower if the worker could be maintained at the same time wage while the enterprise enjoyed the fruits of his increased production. This, however, is neither plausible, possible, nor fair although it has been tried many times in the past by unscrupulous opportunistic managements. Most obvious of these measures are the longer working day at the same daily pay, larger assignments, and rate cutting. The

last may not be too obvious in some cases unless watched closely. It is most generally called the "speed-up" by the workers or unions. These methods are unfair to the worker for one all-important reason which is lost sight of in many cases. The reason is that the workers' time wages or previous wages are implicitly tied to his former productivity level. He receives his wage (determined to a large extent by trial and error) because of the amount he produces, not because of custom; although in some instances custom admittedly will demand that some workers receive more or less than their appropriate share. If a wage reduction is required because of a change in economic conditions it should be the result of collective bargaining or common agreement, not through "underhanded" methods. Regardless of the justice of the case, the workers will eventually reduce production to their former level of productivity if expected benefits of increased productivity are not returned to them. Management incidentally calls this resistance a "slow-down" in certain cases. This is labor's alternative and prerogative which though unrecognized by many managers is nevertheless utilized by labor daily. As Taylor discovered, the workers' opposition to unjust rates may at times take the form of violence or strikes, but usually it will be of the passive sort just mentioned.

By raising the productive level of its employees, the individual enterprise would obviously increase the productivity of its fixed investment. Decreased production time per unit of product will also be a direct result. This decreased unit time of production can mean considerable savings to most businesses through distribution of fixed costs over more units of production, if sales are increased by this. In a competitive situation sales can be increased by passing along part of the savings to the consumer thus benefiting another member of the production-consumption-investment team. Decreased overhead and decreased operating times per piece can many times be accompanied by reduced scrap, less machine down time, less storage capacity required, and flexibility of production capacity to meet changing conditions. Management can also undertake to reduce variable costs by reducing the labor force if increased sales do not result from the increased production. Because of employee morale considerations, this is not generally recommended, unless accompanied by alleviating circumstances such as a scarce labor market, or by assimilation of the excess workers into the organization as replacements for vacancies.

In discussing the above problems, it is not meant to be inferred that the productive capacity of the hourly production personnel is the only one that concerns management.

Output and efficiency of all personnel in an enterprise are subject to considerable improvement, especially those below the supervisory level. Supervisory positions are in themselves a considerable non-financial incentive to the occupants. What is stressed primarily are the wage incentive methods needed for maximum productivity from the hourly personnel, who often have the very minimum of non-financial incentives. This group of employees represents the largest portion of the payroll for most industries and through them the greatest savings can be made. This is true not only because of the numbers involved but also because of the machinery and equipment they ordinarily use. Any increase in the productivity of the operators simultaneously increases the productivity of the equipment used. This multiplying or accelerating effect is especially true in the more highly mechanized industries where savings in direct labor costs may in many cases be small when compared to the indirect results of increased productivity.

Another important consideration is the matter of worker representation and the presence of collective action. The hourly personnel have behind them, in most cases, the force of an organized labor group. Management has been forced to resort to objective methods of dealing with these groups whether the methods are particularly desirable or not.

If the presence of low productivity is so obvious and the results of increased productivity so beneficial, many a management may ask why hasn't something been accomplished toward achieving this objective? In answer to this question, it may be said that in many individual plants quite a few plans have been tried and many of these have been successful in increasing productivity with its resulting benefits. This has been accomplished primarily through the use of financial incentives.

The Benjamin Electric Manufacturing Company of Des Plaines, Illinois, has had an incentive plan in their factory since October 4, 1945. According to Mr. Hoyt P. Steele (1953), it has met with considerable success. He states in a letter of reply to a questionnaire sent to him that:

"As far as performance is concerned, I can say that we are very happy with the reduction in unit costs that have occurred since 1946, and most particularly with the acceptance of this carefully engineered incentive plan by our employees. Average hourly earnings of our employees now exceed \$2.30 per hour, and we are certainly manufacturing our product at relatively low cost in a highly competitive industry."¹

Thus, the company has been enjoying reduced costs while paying considerably higher wages than the average.

This situation holds true of yet another company, George A. Hormel and company of Austin, Minnesota. In a company

1. Steele, Hoyt P. 1953. Letter to Maurice Burke dated January 9, 1953. Benjamin Electric Co., Des Plaines, Ill

publication, the Hormel Company (1943) makes the following remarks concerning their incentive plan: "The rate of production in all of our departments has been most satisfying. The main concern of our supervision is to see that the employees don't work so fast in acquiring the gain that the quality is neglected."¹ If the management must be on guard against the workers "speeding-up" on the job to the detriment of the quality of work, then the plan appears to be a success insofar as attaining its objective of increased productivity. Naturally a successful plan should have adequate safeguards through proper inspection and/or other engineering approaches to prevent an excessive percentage of poor quality work.

Just as a reminder of the dangers of assuming that an incentive plan is inherently good, it may be well to refer to another letter received from the manager of the time standards department of a well-known eastern manufacturing firm.² In commenting upon the success of various incentive plans used by the company, (six different incentive systems were in use at various times during the last forty years) he states that because of the haphazard basis under which the

1. Hormel, Geo. A. & Co. 1943. THE HORMEL ANNUAL WAGE INCENTIVE, AND JOINT EARNINGS PLANS.
p. 6, Geo. A. Hormel & Co., Austin, Minnesota.

2. This reference is omitted due to personal comments.

various plans were operated, potential incentive earnings varied as much as 100%. Such conditions are obviously not promoters of efficiency and increased productivity. If the rates are permitted to vary to such an extent, the incentive is not accomplishing its objective although management may be assuming that operating conditions and productivity are at a high level. The mere presence of a system or plan no matter how imposing does not guarantee efficiency. This must be continually stressed under any plan for increased productivity. Data in the form of cost and production records must be kept and compared against standards previously determined as representing what conditions should be. This will insure through the principle of exceptions that management is made aware of the actual results of their policies.

It may be seen from the above examples that increased productivity through incentives is attainable but constant observation and control must be maintained over the conditions which make this possible.

Labor and labor organizations have been at times strongly opposed to plans which will increase the productivity of its members. In many cases, opposition to or support of such plans has been due to past experience of the union members or union officials under apparently similar plans. This explains the sometimes wide variations in opinion among

various unions concerning such plans. The United States Department of Labor, Bureau of Labor Statistics (1948), found that past experience was a large factor in contributing to either acceptance of or opposition to incentive plans. Their statement is as follows:₁

"Much of the opposition of workers to incentive plans is due to past experience with rate cutting and the speed-up. The claim has been made that whenever workers become adept at an operation and increased their output, and thereby their earnings, management would re-time the job and cut the rate for the operation so that workers turned out more with no corresponding increase in pay. Piece rates were sometimes lowered without clear justification, or on the ground that some adjustment in machinery or process had warranted a re-timing of the work. Even when rate changes were justified by some change in operations, workers often felt that a more than proportionate reduction in rates had been made. Management also would re-time jobs after workers had hit their stride and then set the new, high production level as the normal standard for base pay resulting in a speed-up.

Other reasons for worker antagonism to wage incentives include: general distrust of the impersonal nature of time study methods; fear of loss of jobs resulting from expanding output per man; dilution of skills caused by break-down of crafts into semi-skilled operations; competition among workers and variations in earning, leading to splits and divisions tending to break up the cohesiveness of the union, etc."

The pamphlet goes on to state that these are far from being universal beliefs on the part of the union leaders and that many press primarily for insertion of arbitrary demands

1. United States Department of Labor, Bureau of Labor Statistics. 1948. COLLECTIVE BARGAINING PROVISIONS, INCENTIVE WAGE PROVISIONS; TIME STUDIES AND STDS. OF PRODUCTION.
p. 2, Government Printing Office, Washington, D. C.

chiefly as safeguards in the union contract. These safeguards are aimed primarily at elimination of the abuses mentioned. The completeness and stability of bargaining relations in the clothing industries where piece-work incentives are the rule appear to substantiate the latter statement. Some of the fears are evidently holdovers from the days when employers set the rate on the job at the fastest time it had been done previously. Without qualification, it may be said that the majority of the truly successful enterprises have abolished these practices in their plants.

It would seem, at first glance, that with all the substandard living conditions still existing today that labor would only be too glad to help relieve them by increasing its productivity. This would appear to be especially worthwhile when the workers wages would be increased in proportion to their increased productivity. The underlying opposition on the part of the workers and their representatives is grounded on the belief that any increase in productivity per worker would result in an overall decrease in employment. They generally hold consciously or subconsciously, that there is a fixed output which the economy can absorb at any one time. Therefore, they feel that if individually they are more efficient and receive more money for this efficiency, it will be at the expense of another worker or group of

workers. In other words, unless there is an increase in investment there will be no increase in demand, given a relatively fixed propensity to consume; and some workers as a natural consequence will be idle. Labor may be said to have adopted to some extent the Keynesian approach to the economics of the problem. Management on the other hand tends to view the problem of production from the view point of Classical Economics. This relies on Says' Law of Markets which Dillard (1948) states simply as "supply creates its own demand."¹ Contemporary economists hold that the true situation is probably somewhat between these extreme views. If labor increases its productivity, the people with the highest propensity to consume will receive the greatest increase in wages. If the savings is passed along to the public in the form of lower prices, then still more goods may be bought. Very little new investment, if any, will be needed in this case to keep up with the new output. This may be provided by either private capital or government investment, if necessary. Furthermore all workers in the United States have another strong bulwark to fall back on. It is the full employment law passed by Congress which directs the President to use his powers of office to maintain

1. Dillard, Dudley. 1948. ECONOMICS OF JOHN MAYNARD KEYNES. p. 18, Prentice Hall, New York.

full employment. This law makes maintenance of full employment a direct responsibility of the President who must use all resources at his command to maintain it.

This is cited to make a more convincing case for incentives and increased productivity. If at any time increased productivity did put people temporarily out of work, either natural occurrences or governmental action would assure them of a job within a relatively short period. Regardless of absence or presence of these provisions, decreased productivity would still be harmful to society as a whole. It is obviously not a long range solution to unemployment. One possible solution upon obtaining increased productivity would be to shorten working hours while maintaining the same or a greater working force. With the increased wages through incentives and greater leisure time the workers could maintain or increase their standard of living notwithstanding the reduction in their working hours. Total employment could still be maintained or increased.

To a limited extent, the employees also believe that the employer will somehow manage to partake of that portion of the fruits of the increased production which they believe to be peculiarly theirs. This belief is based on the results of increased productivity as they have seen them practiced by many companies in the past, where the workers were returned

only a portion of what was due to their efforts. Also, many companies in the past reduced the number of employees on their payroll simultaneously with the introduction of an incentive system or methods improvement. This is obviously an incorrect practice which is avoided by progressive companies and capable managements wherever possible. As an alternative, they can institute the system gradually, in many cases, and either reassign the displaced workers or slow down the change over until the increased production resulting from passing on of the savings to the consumer makes other jobs for them. In many cases, displaced workers can be used to replace the normal turnover in a company. If an incentive system is adopted intelligently it need cause no harm to the workers through unemployment. In any event alert management should always be prepared to take advantage of the sales possibilities created through the increased productivity of the present investment before considering additional investment in plant.

In contrast to the feeling on the part of labor that increased productivity means decreased employment are the prevailing social values which underlie our present wage system. The prevailing attitude of the people of this country is that if a person has achieved financial success he will attain prestige. In short, one is the natural accompaniment

of the other. In fact, many companies have relied and are still relying on this belief to achieve increased productivity on the part of the workers. Often they have not even attempted to help or guide the worker to attain that productivity. Taylor (1911) called this management by initiative and incentive. Management of this type relies upon the worker to produce more regardless of working conditions and in many cases in spite of them. It does not recognize that increased productivity is a two way street. Labor and management are both limited in the amount of joint, overall success they may achieve without extensive cooperation.

If this spirit of cooperation exists on the part of management and on the part of the employees, we may say that we are approaching the concept of Scientific Management as outlined by Taylor. The same essentials of good management have been brought out in the more recent book by James F. Lincoln (1951), president of the Lincoln Electric Co. The underlying theme of Incentive Management as advocated by Lincoln mirrors Taylor's Principles of Scientific Management. This is illustrated by the following quotation from Lincoln's book.

"It is the responsibility of management to find the most efficient way of doing any job. This is not the responsibility of the operator. If the operator is continually

able to find the more efficient methods of doing the manufacturing operations, then management is useless and should step aside in favor of the worker who has outperformed him. If management has no essential function in developing the manufacturing methods used, of what use is it? It will find difficulty in justifying its existence and salary.

When management discharges its responsibility as the deviser of more efficient methods for doing the job in question, then it is its responsibility to teach these methods to the operator."¹

To use the above system of management effectively, Lincoln postulates that an essential accompaniment of his system is cooperation between management and the workers. Without this cooperation, full productivity cannot be obtained and necessarily the lowest possible costs of production are not reached. This cooperation is to be obtained only over a period of time as the workers come to understand and trust management and to look upon management as another skilled member of the production team, rather than as an overseer. Both the Taylor system of Scientific Management and the Lincoln system of Incentive Management advocate management highly skilled in production methods and capable of bringing them to the operator who has been trained properly to do his work. This means that there will be a proper division of work between management and the workers, and that the management will not rely on the workers to devise alone the newer

1. Lincoln, James F. 1951. INCENTIVE MANAGEMENT.
280 pp. Lincoln Electric Co., Cleveland, Ohio.

and better means of production, even if it were possible in this day of complex technology. Cooperation is the underlying objective of both systems. The type of management advocated by Taylor and Lincoln is the approach to the problem of incentives in industry as presented in this thesis.

We are concerned here with several of the many tools of what is commonly referred to as Scientific or Incentive Management; incentive systems and the various Industrial Engineering methods and techniques necessary for their proper operation are among them. When pursuing such a program the management must also make substantial contributions to the productivity of its employees. It must provide such services to the employee as he will need to attain a peak of efficiency. As a contrast, management by initiative and incentive merely provides the worker with an incentive for increasing his productivity. Through ignorance it makes little attempt, if any, to alter the working conditions, methods and procedures in such a way as to aid the worker. In a sense it may be said that this system relies hopefully upon the worker to investigate every means within his command and utilize them as efficiently as possible to increase production. It must be observed, however, that the worker as an individual usually has very little to work with in the way of facilities or specialized technical knowledge when compared

with that which management may make available by recourse to accumulated resources of the whole enterprise. The worker must, when left to himself, increase productivity primarily by his increased exertion. It is admitted that in itself this can be a great contribution, but it is pitifully small when compared to the results possible through Scientific Management. Management has a much greater capacity not only because of its access to greater resources but also because of its overall approach to the problem. Management must, therefore, utilize this inherent capacity to aid its employees, if the declared objectives of the free enterprise system are to be attained within the democratic structure of contemporary society.

As an individual at the bottom or near the bottom of the chain of command in an organization the worker has little or no authority to put into effect his ideas or methods. He must usually confine himself almost entirely to his work area. If he is working as a part of a gang or crew of employees his chance of effecting improvement in productivity through his own efforts is even smaller. At the very least, he must obtain the cooperation of either management of the company or of the group if he is to put into effect an increased tempo or new methods. The group's informal leader (i.e. individual of the group who naturally assumes the role

of spokesman or leader of the group by virtue of his acceptance as such by the group) could possibly persuade the group to adopt the methods or tempo if they thought it in their best interests to do so. Even then one individual can reduce the collective effort. The informal leader must convince each and every member of the group that it is to their best interests to cooperate. Therefore, we may conclude that at the very best the system of management by "initiative and incentive" is limited and is used primarily as a substitute for able, informed management.

The answer to the problem of increased productivity must be obtained by providing the worker with an incentive to do better and accompany this incentive with Incentive Management. Results obtained by either group working individually is very limited in comparison to that obtainable through harmonious action on the part of employees and management. Adapting an incentive to meet the various situations is a complicated matter. It is complicated further when management comes to believe that incentives are automatic cost savers and as a consequence fails to do its share to contribute to increased productivity. We must conclude then that there should be a constant check through measurement of any incentive system. Otherwise the workers will eventually slip back to their former level of low productivity while

enjoying the increased wages that went with the increased productivity. Pressure for concessions will come about through collective bargaining, through grievance procedures, or in a general slackening of incentive standards on the part of management. It is not meant to be inferred that opposition to concessions is an opposition to increased wages to the workers. What is meant, is that when the employees need to receive a pay raise it should be accomplished through raising their base wage and not by lowering the conditions on which the incentive program rests, and thus destroying the productivity incentive.

Many industries could have almost completely automatic plants if management so desired and if the costs were not prohibitive. Overall control of such a plant would be almost entirely an engineering function as is control of the individual processes of a partially mechanized plant. As mentioned previously the most obvious alternative to the use of hourly employees in a plant is mechanization. However, regardless of this aspect, even when machines are used without complete mechanization and automation, the workers are primarily servants or tenders of the machines. Incentives attempt to obtain maximum productivity from the workers, yet remain well within the limits of human capacity, in order to minimize the overall costs of production. If this is not

done the cost of labor may become prohibitive and thereby force management to rely on greater mechanization. As the cost of labor rises, the advantages of mechanization become ever more apparent. This may in itself be a good thing as mechanization usually increases per capita productivity which raises the standard of living, as has been evidenced at least during the past century.

We have been speaking of the simplest and usually the best form of incentive so far, the individual incentive. Another problem presents itself when we consider workers in group activities. How can we provide the incentive to obtain maximum productivity? The answer generally appears in the form of a group incentive. This group incentive may appear in the form of pride of workmanship but will be greatly influenced by wages, in most cases. There are certain points to keep in mind regarding an incentive of this type. The foremost of these is the principle of keeping the incentive group as small as possible. In a small group there appears a natural, informal leader (previously mentioned) who under incentives attempts to have everyone do their share toward the group objective. When the group becomes too large it becomes difficult for the natural leader to retain control over the group or for the group to exercise its majority rule. It is a problem delegated by management to the foreman

to see that the group maintains a high rate of productivity, but his job is lightened to a considerable extent by this natural tendency of the group to regulate itself, assuming it has confidence in the incentive. Incidentally, the group will act in entirely the opposite manner if they have no confidence in the incentive offered by management or feel it to be insufficient. The result in this case would be a general slackening of production and constant guard against attempts to achieve greater productivity by management. This collective action, seldom clearly postulated, is merely one of the devices of the workers to protect themselves from an unscrupulous management.

Profit-sharing is a type of financial incentive which will be mentioned only briefly in this thesis. It is primarily an administrative function and as such is not an engineering activity. Three major pitfalls of this type of incentive should be mentioned however. First, it usually involves a reward that is somewhat distant in the future and psychologically loses much of its value as a consequence. Second, while the workers will naturally and willingly participate in the profits of business, they will not share the losses and actually cannot afford to. If losses occur during a period of high employment and wages are tied in with profits then the workers will seek employment elsewhere. At the very

least they would probably strike before accepting wage cuts in the form of no bonus for increased productivity. Third, the workers will eventually tend to regard profit-sharing bonuses as their privilege or right and will resent any situation or management that takes away what they regard as rightfully theirs. They cannot visualize how their individual production will have any bearing on the company savings. Profit-sharing makes the workers wages dependent upon business success rather than on individual effort and this in itself (except under unusual circumstances) gives no spur to the productivity of the worker.

Previous to the industrial revolution there were prevalent what may be called natural incentives to produce well. This natural incentive is still present in the small business where the worker knows his employer intimately. The journeyman of the handicraft system had hopes of becoming a master some day so his sympathies were naturally on the side of management. In many cases the master was the worker's personal friend. At the very least, workers as a whole did not have the collective approach to their problems that has become prevalent with modern industry. The work unit was small and therefore increased productivity in one shop would not materially affect employment in that shop or in another.

It is no longer practicable to rely on the natural means

of incentives because of the increasingly impersonal relationships that exist between management and the employees and above all between the outside stockholder-owners of industry and the workers in the factories. This problem is ordinarily handled through financial incentives although non-financial incentives are used. It is not possible to buy everything with money but neither is it possible to rely too much on non-financial incentives because of the dangers of sliding into objectionable paternalism. Paternalism frequently arises when management attempts to direct the activities of its workers outside of working hours, in effect by retaining a part of their salary and spending it on programs management feels will be to the best interests of the worker. Taylor (1911) found long ago that monetary incentives alone, however, were not enough, and that in the case of the pig iron handlers at Bethlehem Steel Company approximately 60% over the going wage was the optimum monetary incentive effective at that time.

Today we must design our incentive systems to match the complex society and complex organizations of industry. In this regard, the National Metal Trades Association (1949) has stated "----, it should be noted that experience indicates that a new company, industry, or organization which is

rapidly expanding, or one starting the processing of products not common to its normal line, should approach the installation of incentive methods of wage payment carefully."¹ From this statement it is possible to draw an interesting parallel between management of production workers and management of management. When a factory employee is assigned a new job or one with which he is not thoroughly familiar, management makes allowance for the lack of familiarity in the production goals that are set for the worker. Management should apply this insight to its own practices by avoiding early standardization where and when it is not beneficial. Without a thorough engineering knowledge of the operations and products, management should rarely attempt to introduce an incentive system because, of necessity, this must be accompanied by standardization. If standardization is attempted under the foregoing conditions, time standards will soon become inaccurate or will be incomplete and thus create a situation which will tend to undermine the whole incentive program. The NMTA (1949) states further that standards will be hazarded by the following conditions:

"1. Rapid changes in design that necessitate readjustment of equipment, methods, tooling, materials and

1. National Metal Trades Association. 1949. INDUSTRIAL RELATIONS POLICIES AND PROCEDURES BULLETINS NO. 3, PARTS VI, VII.

p. 1, National Metal Trades Association, Chicago.

2. Ibid.

- consequent changes in basic times.
2. Difficulties encountered when employees are transferred from incentive earning jobs to day work having a lower take-home pay.
 3. The multiplicity of problems involved when standards are set too high, as a result of haste and inexperience.
 4. Lack of familiarity of operators with work."

The above mentioned hazards will only be intensified under conditions which are constantly changing. Therefore, introduction of an incentive system under conditions which are changing is not to be recommended. Cost of maintaining standard conditions will be too expensive in comparison to the benefits involved.

There are certain very definite activities which management must perform to make a financial incentive plan a success. Several of these such as time and motion study and standardization will be covered in detail later in the thesis. As only one of the tools of industrial engineering, incentives cannot be used alone but must be supplemented and become a complement of the other tools.

Time and motion study is an integral part of a financial incentive plan because it alone can provide the accurate measurement system needed to determine the payments that will be made. It also standardizes the workplace, and along with "plant layout" it standardizes the complete work area. To be fair to the workers as well as to provide them with an accurate basis for determining their increased productivity,

work conditions must often be highly standardized. If not, time and motion study will be ineffectual, since its engineering utility is predicated on performing tasks of work in previously established routines under standardized conditions.

To determine an increase in worker productivity his current production must be measured against the previous rate of production under similar standard working conditions.

Lincoln (1951) states this in somewhat the same manner when he indirectly refers to time and motion study in the following statement:

"Incentive Management is becoming of progressively greater importance as our mechanization of productive operations advances. When a man dug a trench with a spade, any boss could tell if he was working and how hard. No boss can tell accurately now whether a man operating a ditch digging machine is doing his best, trying to limit output, or is actually wrecking his machine."¹

There has been a tremendous increase in the complexity of production machines and processes since the advent of the factory system and mass production. With this increased complexity has come the realization on managements part that to accurately determine the production a worker should achieve a detailed analysis of his work should be made using time and motion study. Only through this detailed analysis is it possible to determine the proper unit time of production.

1. Lincoln, James F. 1951. INCENTIVE MANAGEMENT.
280 pp. Lincoln Electric Co., Cleveland, Ohio.

Another necessary preliminary to the installation of an incentive system is a program of job evaluation which determines the requirements of each job and ranks them in order of their relative economic value to the enterprise. Job evaluation must begin with a job analysis which requires that a detailed study be made of every job (or job class) to determine the requirements of the job, the conditions under which it is performed, and detailed characteristics of each job. Usually some point system is established which denotes the degree of difficulty or presence of a particular characteristic such as working conditions, education, training, responsibility and authority. These points are then added to obtain the relative worth of the job to the enterprise. After this is done to all of the jobs a classification system may be set up which will be that basis for a pay scale which will be negotiated between the union and the company. Thus, it may be seen that this definitely ties in job evaluation with an incentive plan. Job evaluation establishes a program of job standardization which is built around the standardized conditions under which the employee will produce. Job evaluation also ultimately determines the wage rate for a particular class of jobs in the factory.

An employees' suggestion system is also needed if the individual employee is to be given adequate recognition for

his contributions which will permanently or even temporarily improve his work and/or the work of others. A suggestion system is really a reward system for personal inventiveness on the part of the worker and is concerned with suggested improvements in methods, processes, and machines of production. A well set up suggestion system should reward the worker in some clear cut manner for improved methods and good ideas. Many of the present systems fail to give credit to the worker for his ideas concerning workplace arrangements, etc. The suggestion system can be a very important tool for bringing these ideas out of hiding where they would be kept by the workers if not rewarded for them. For example, take the case of a worker who doubles the output on his machine by increasing the speed and feed. If he expects no reward for the idea, he will keep quiet about it and reduce the expenditure of effort on his part until he is merely loafing on the job a good portion of the time and still making his incentive. He is repaid to the extent that he can reduce the effort involved on the job, but management is unable to use his idea on other similar work. If the suggestor is adequately paid for his ideas then they will be brought forward for the use of others. Needless to say the reward should adequately compensate the worker for his idea and not be a mere token of management's good will.

Production planning and control is also a necessary accompaniment of an incentive system. This function is responsible for the coordination of work in the plant through proper planning and scheduling. It enables an operator to be working on an incentive basis with a minimum of interruption and under standardized conditions. It is the responsibility of his "department of coordination" to assign the worker to a machine or to machines which are called for on the standard instruction sheet and which enable the operator to work under an incentive rate. Conditions which deviate from standard will often necessitate that the operator work on a straight-time basis for the duration of the job. Planning should also insure that the worker is on a job long enough for him to get the "feel" of it so that he may attain his peak productivity. Good production control eliminates unnecessary delays for the operator and assures proper performance of assigned functions. Plant layout is a necessary accompaniment of good production control. Proper layout will allow for convenient location of materials, and of the various tool, gage, and manufacturing "cribs." Systematic flow of materials through the process or through the plant is another important objective of plant layout. Work place arrangement should be made so as to facilitate the flow of work rather than to obstruct. Preventive maintenance is also necessary. Machines must be kept in proper working

order for the sake of dependability and to enable the planning department to forecast accurately future conditions and thereby meet production commitments.

The adoption and use of wage incentive plans is evident upon consultation with a table used by Alford and Bangs (1949¹). The table is a compilation of data gathered by the National Industrial Conference Board. Of 2700 companies contacted, 75% used wage incentives. The companies that were analyzed for this purpose in this chart were 313 of those which furnished the most specific information. This analysis shows that company size makes no material difference as to the use of incentives. Of the manufacturing companies surveyed, 75% were using wage incentive plans. The survey covered 900 manufacturing companies in all. An additional fact gathered from the studies was that at that time no one incentive plan or any few particular plans showed a tendency to supplant the many plans presently in use. Thus there would appear to be no plan devised as yet that would be anywhere near applicable to the conditions prevalent in a majority of the manufacturing companies. It gives substance to the belief that an incentive plan must be adapted to each plant.

From an analysis of the report it would appear that

1. Alford, L. P. and Bangs, J. R. 1949. PRODUCTION HANDBOOK.
p. 1174, Ronald Press Co., New York.

incentives are particularly useful in the manufacturing field as is evidenced by the fact that 75% of the manufacturers contacted used incentives. Manufacturing industries have utilized industrial engineering as has no other business activity and will seemingly continue to do so to an even greater extent in the future. Although this use of industrial engineering rests in many cases upon the needs of the incentive systems it exists without them. Regardless of the Industry, however, incentives cannot exist without industrial engineering.

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Chapter II

FUNDAMENTALS OF FINANCIAL INCENTIVE SYSTEMS
AS APPLIED TO INDUSTRIAL MANAGEMENT

Wage or financial incentive systems are a natural outgrowth of wage plans in general. In actuality, any part of a wage in excess of the bare minimum required to attract a man to a job and give him sufficient money to exist on, is a wage incentive. This wage incentive, existing even when an employee is being paid by the hour, is designed to attract and hold workers of the required caliber and satisfy them sufficiently so they will produce an optimum amount on the job. As an outgrowth of straight day-work wages, where an employee receives an hourly wage, wage incentive systems have been developed.

Incentive wage systems are designed to compensate a worker for more than normal productivity while on the job. Admittedly, given a suitable environment, this could also be done by so-called non-financial incentives. However, many companies have adopted incentive wages as a supposedly satisfactory solution to obtaining increased productivity from their workers.

Incentive wages, as such, were one of the first contributions of scientific management as advocated by Taylor (1911). Various plans have appeared, each seeking to obtain increased

employee productivity in its own manner. Generally these plans have adopted the name of the originator, thus the Halsey, Gantt, Rowan, Bedeaux, et cetera plans. Industrial engineers, working independently on their respective plans, developed almost identical systems which bear different names. Insofar as practicable, in this thesis, differentiation will be made only among the basic plans.

To be fully successful any wage payment plan must include certain basic considerations essential to its operation. Scott, Clothier and Spriegel (1949) have developed the following objectives that should be included in a satisfactory plan:₁

- "1. The wage should be related to the individuals productivity with differentials for various factors such as skill, versatility, class of work, working conditions, etc.
2. The wage plan should be easily understood by the employee.
3. The wage program should be easily related to the budget and cost control system.
4. The wage system should facilitate the comparison of the efficiencies of the various departments.
5. The wage plan should make adequate provision for learners.
6. It is desirable that the wage program should not involve excessive clerical detail.
7. It is desirable that the wage program should insure the worker a guaranteed minimum wage to protect him against conditions over which he has no control."

Other factors to be considered in the actual process of wage

1. Scott, Walter D.; Clothier, Robert G.; and Spriegel, William R. 1949. PERSONNEL MANAGEMENT.
p. 351, McGraw Hill Book Co., New York.

determination are numerous. However, most of those not listed above are responsibilities of the collective bargaining and job evaluation functions of the organization.

The success of existing incentive wage plans has been varied depending on the management and the employees. Yoder (1948)¹ relates that a study of such plans in 1942 found that median employee earnings ranged from 12.1% to 18.2% higher than day work wage plans. A second survey in the same reference found that in several plans analyzed, hourly output increased 38.9% with a reduction in unit labor costs of 11.58% while take-home pay increased 17.56%. The National Metal Trades Association (1949) believes that it should be possible for a worker to receive 20% to 30% above his normal base pay when working under an incentive wage system. Evidence of above normal earnings is indicated by this excerpt from a letter received from E. J. Walsh (1953) of the National Foundry Association:²

"In reply to your question, I am happy to give you my opinions for what they are worth. Foundries having established incentive plans have experienced considerable success through these plans. Production in these foundries is up well over the non-incentive plans and earnings as evidenced by the wage and earning reports we receive are considerably higher in the incentive plans than they are in the day work plans."

1. Yoder, Dale. PERSONNEL MANAGEMENT AND INDUSTRIAL RELATIONS. p. 399, Prentice Hall, Inc., New York.
2. Walsh, E. J. 1953. Letter to M. W. Burke dated January 15, 1953. National Foundry Association, Chicago.

The above statistics illustrate two of the basic reasons for having incentive wage plans. The first is to increase the overall plant productivity. The second is to pass the benefits of this increased productivity along to all associated with the enterprise. This latter reason means passing the savings to the employee for his participation, to the company for its, and to the general public as the final recipient of the end product. Some of the advantages included in the above have been outlined by the Pittsburgh Plate Glass Co. with this statement:

"A wage incentive system, if effectively applied and administered, will result in many benefits to both management and labor such as:

1. More equitable earnings through payment of wages varying with the productivity of the employees.
2. Greater job security resulting from increased demand for manufactured products through lowering of unit costs and/or improvements in quality.
3. Improvements in planning and scheduling.
4. Increased accuracy in cost estimating."

Many other advantages are attainable but, it must be emphasized, not merely through institution of wage incentive plans alone. They must be accompanied by whole-hearted management participation. Even then a plan must be measured in terms of its overall contribution to manufacturing costs. Lowered direct-labor unit costs do not necessarily mean lowered overall unit costs. Conceivably indirect costs could rise

1. Pittsburgh Plate Glass Co. PROCEDURES & PRACTICES FOR APPLICATION & ADMINISTRATION OF THE WAGE INCENTIVE SYSTEM. p. 1, Pittsburgh Plate Glass Co., Pittsburgh.

sufficiently with the installation of a wage incentive system so as to negate the effects of increased direct-labor productivity.

As will be shown, incentive wage plans should be applied only where work output can be measured. This factor limits the application of incentive systems to production workers or production service workers in many plants. Workers with such jobs as janitors, elevator operators, and the like are usually not included in the plans. Through proper methods, it is possible to measure their work efficiency, but to date utilization of such methods has been confined to only a few of the larger companies in the United States.

This technical limitation of the typical incentive wage system to work that can be directly measured leads to qualifications in the system itself. It is generally agreed that incentives are most effective when applied to individuals. The Minnesota Mining and Manufacturing Co. (1953) has followed this policy in their wage incentive programs. They state: "Direct reward to an employee provides the greatest incentive to increased productivity and reduced costs. For this reason, payment is based on the work of an individual or small group."¹ This illustrates the inability of a typical company to always confine work measurement to one individual.

1. Minnesota Mining & Manufacturing Co. 1953. 3M INCENTIVE POLICIES. p.3, Minnesota Mining & Mfg. Co., St. Paul

As a compromise solution, several individuals are included under one incentive. For instance, take a group of three men running a paper machine. Their collective effort is registered as the tonnage produced on the machine during their shift. No differentiation is ordinarily possible due to the individual productiveness of any one of the three machine tenders. However, lack of alertness on the part of any one could at certain times affect disastrously the output of the machine and the earnings of other tenders. Incentives, if applied, must therefore be on the basis of group effort. Yoder (1948) emphasizes, however, that group compensation plans are very similar to individual incentives in application. The difference being primarily that premiums depend on the group output rather than individual production.

Some similarities and many differences are to be expected in the plans of the various "tailor made" systems of incentive payment. Special provisions can be included for such varying conditions as quality, minimum wage, step-increases, and slope of the wage curve. However this may be, to be certain of successful operation management must make certain preparations before and not after installing a wage system, namely:

1. Analysis of industrial engineering procedures and progress in the area to be covered. This includes a construc-

tive review of the plant layout, materials handling methods and equipment, and work procedures. Standardization should be developed where possible.

2. Institution of a job evaluation program if not already present. Work assignments may have to be shifted in some cases to make incentive earnings possible to all covered employees. Balancing of the workload will be necessary.

3. Establishment of a program of work standards through motion and time study. The incentive system should be installed with as near 100% coverage as possible for time standards. Written standard practice sheets should be issued for each job no matter how small. The minimum coverage for time standards and standard practice instructions should be 90% according to the Minnesota Mining and Manufacturing Co. (1953).

4. Obtain an agreement with the union as to the operation of the plan under the union contract and also to the coverage of the various wage classifications. A prevue of the plan is equally desirable at times. In this phase of installation, the National Association of Manufacturers (1946) makes this observation:₁

"It must be recognized that for any incentive plan to produce results, there must be no limitation of output of the

1. National Association of Manufacturers, Ind. Rel. Dept. 1946. INFORMATION BULLETIN NO. 5, p.4, National Association of Manufacturers, New York.

individual worker, and this must be agreed to by the unions. Management on its part, must agree that after a permanent standard is once set, the standard will remain unchanged, unless there has been a change in equipment, work specifications, in method, design, or in other controlling conditions."

5. Provide for employee protection against the possibility of reduced earning power when the plan is instituted. Usually, provision is made for the old base rate to become the guaranteed minimum rate of pay under the new plan.

6. Explanation of plans to supervisors and employees. This is probably the most important factor in the success of an incentive wage program. Participating employees and supervisors must understand the program. Especially, the supervisors should be indoctrinated early in the workings of the plan. Theirs is the front line position in regards to such a system and they must be prepared to answer questions and explain it to employees under their jurisdiction. Employees will go to their foremen for explanation of features or vagaries of the plan. This necessitates close familiarity on the part of the foreman. A successful aid for supervisors has been instituted by the Minnesota Mining and Manufacturing Co. (1953) in this respect. They issue an "Incentive Plan Bulletin" explaining the incentive plan to be applied in a particular department or plant. Details of operation along with examples of payment calculations are included in the pamphlet which is distributed to all affected employees.

Pertinent features of time study and incentive coverage are also included. Supervisors are thus relieved of the necessity of answering routine questions concerning obvious features of the plan. Misunderstandings are reduced to a minimum as the workers can refer to their explanation sheet whenever questions arise in their mind.

PRINCIPLE AMERICAN WAGE PAYMENT PLANS:

1. Time Rate Plan--This is the best known and most widely used of all wage payment plans. It is predicated on the theory that a man is hired to do a days work and during it to accomplish an established task or series of such tasks. Time rate plans, as the name implies, provide a wage which varies with time alone, not with production. In itself, it has very little incentive for obtaining high rates of productivity from the employee as there is no relationship between wages received and productivity.

The time rate plan is used often and very satisfactorily where various supporting measures, primarily non-financial incentives, are feasible of application. Most exemplary of these are security or opportunity for promotion given to the outstanding employee. Others may be such small things as the absence of time clocks, variety in assignments, opportunity for training, promotion from within policy, absence of close supervision and liberality in vacation schedules. In many

cases it may merely be a company policy of treating the employee as an individual subject to individual needs and desires.

The time wage plan is supplemented often by a financial incentive known as merit-wage-increases which is used for employees of high productivity levels. These increases then become a part of the regular time wage and thereby cause little additional overhead for the plan's operation. The employee is encouraged to do better in hopes of receiving the "merit-wage-increase". Unfortunately, the merit increase plan is frequently operated so as to give the feeling that it is an automatic plan in terms of time in service. Employees then come to expect the increase at certain intervals of time and if not give one, the omission becomes a source of ill feeling. This type of incentive payment is usually used for white collar workers and supervisors.

An adaptation of the time wage plan is the "measured day work" plan. "Measured day work" as an incentive rests on periodical judgment of the employees on both tangible and intangible personal qualities. These are weighted and applied to the base wage until the next evaluation.

As a guarantee in connection with other plans, time wages are also of considerable importance. Time wages are required as certain legal minimums since the passage of the Fair Labor Standards Act and other laws dealing with Federal

activities.

2. Piece Rate Plans--The usual piece rate plan is the simplest of all the wage incentive plans. It means literally a constant rate of pay per unit of work for all units properly produced from zero up. The so-called high piece rate plan maintains an employee earning curve equal to 1.30 times the basic piece rate times the number of pieces. The fraction varies depending on the particular application. A modified piece rate plan is now the most popular and is even required by law in certain jobs if a piece rate is desired. It is the piece rate plan with a guaranteed minimum total wage per hour.

Piece rate plans are based on the principle that all indirect savings due to greater distribution of overhead belongs to the employer. Conversely, that all direct savings due to higher productivity belong to the employee. There is actually no rigorous foundation for this reasoning if examined closely.

Consider the typical company which has an hourly wage arrived at by collective bargaining before the advent of an incentive wage plan. This rate was bargained for under the current circumstances, quite commonly production at less than 80% of standard and often considerably less, and with the normal overhead costs per unit at the current production level. Then an incentive wage plan is installed, a piece-

rate plan for example. As a consequence, let us assume, an employee produces at 120% of the newly set normal. But his piece rate wage is based on his contribution to the efficiency of the enterprise at 80% of standard. Also, management has probably installed additional accounting procedures, time standards, possibly a job evaluation program and other refinements. Who can say without careful study of all the facts whether management should receive only the indirect savings or the employees the direct savings. The true relative apportionment of the savings can be arrived at only by a function similar to job analysis and job evaluation. Relative contributions should be determined for the increased level of productivity, possibly for a range from 80% to 150% of standard. From this data can be determined relative sharing of savings. Collective bargaining for wage rate changes can alter the monetary value of wages each employee receives. The percentage or slope of the incentive curve, however, should ordinarily remain constant after the original adoption under circumstances which relate it to the actual contribution made.

The high piece rate plan adopts in part the foregoing principle by having the piece rate curve intersect the unity time rate plan at about 75% efficiency. See figure 6 for an illustration. This is more generous than ordinary

piece work which assumes that productivity before institution of the plan was 100%, which it rarely if ever is.

Thus the high piece rate plan has a feature related to the true state of affairs. Many other plans modify this to encourage beginners or provide more incentive at certain levels of production in order to achieve a higher average productivity upon which the plan can be based.

3. Differential Piece Rate Plans--The earliest of the differential piece rate plans is the Taylor (1911) Differential Piece Rate Plan. Introduced by Taylor in the '80's, it was the first of the wage incentive plans based on time study and other industrial engineering practices still in use today. Unfortunately it was designed to appeal to the exceptional worker and after the development of other plans, it fell into disrepute. The principle of the plan, that of differential piece rates, is very much in use today, however.

Taylor's plan started out with a so-called "punitive piece rate" up to 100% efficiency. At this point, the employees piece rate jumped from 80% to 120% of prevailing time rates. From the point of 100% efficiency upward, the employee received high piece rate.

The reason for the step is obviously to provide a greater incentive to produce above the standard. The idea was good and an improvement over the age-old straight piece work plan.

However, the relatively high performance required before an employee could earn an incentive combined with the punitive rate below high task made the plan extremely unpopular with the majority of the employees. Taylor's idea was to hire only first class workmen for each job with the idea that each man is peculiarly suited for a particular type of job. The plan worked successfully for years under Taylor's immediate direction but when applied under circumstances other than those for which it was designed, the plan was found to be impractical. The idea was adopted and modified by two of Taylor's associates however, and installed under two different plan names.

The Merrick Differential Piece-Rate Plan (See Figure 7) was developed to meet an emergency problem at the Winchester Repeating Arms Co. where the employees disliked the Taylor punitive rate. He designed a plan with two steps, one at 83% of high task and another at high task. This overcame objections to Taylor's plan because of the high productivity required before receiving an incentive. A further modification was to eliminate the punitive rate. Merrick's plan allowed straight piece-rate up to 83% of task with a 10% bonus jump at this point. This rate continued to high task where an additional 10% bonus was applied. The result was three piece rates which admittedly lose

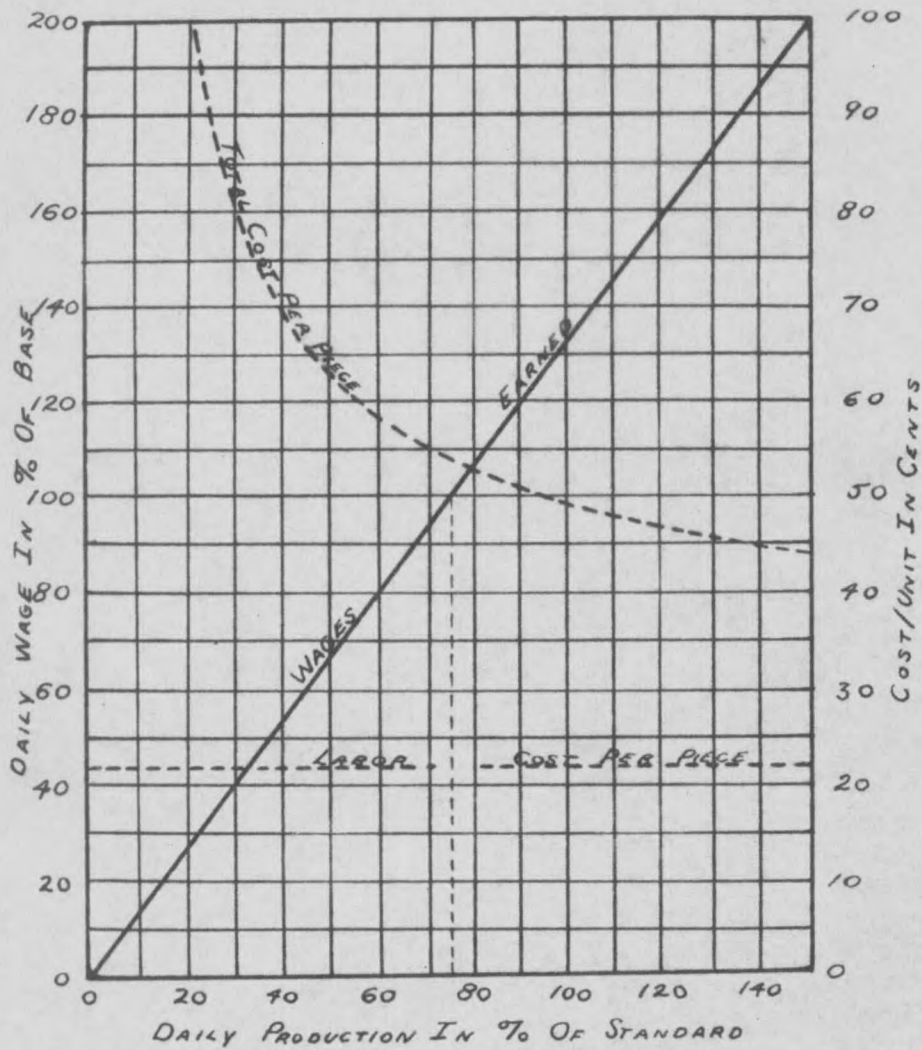


Figure 6
High Straight Piece Rate Plan

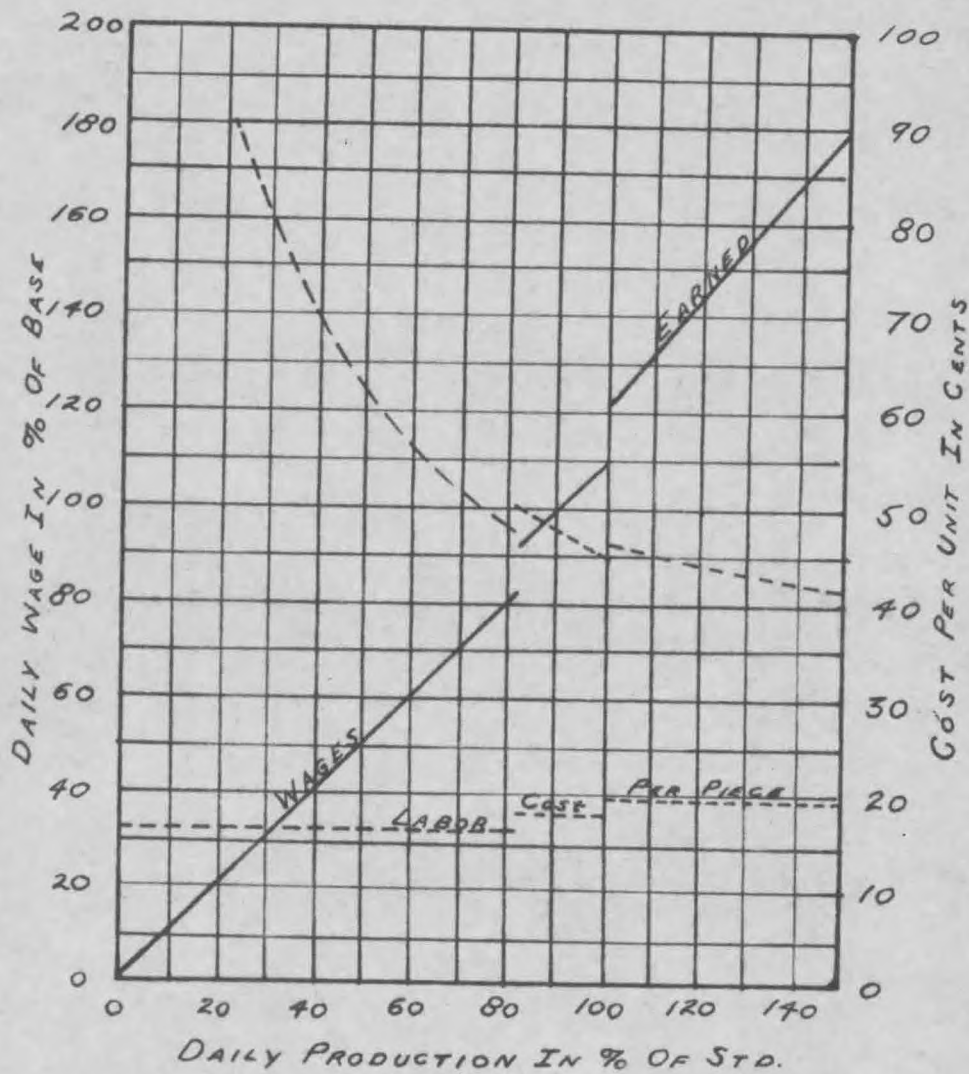


Figure 7
Merrick Differential Piece Rate Plan

some of the motivation potential of the single large step but has a beneficial effect in developing employee productivity. A job under the Merrick Plan is attractive to new or prospective employees as well as to experienced, developed employees. Perhaps the psychology of the Merrick Plan, more than any other feature, was responsible for its acceptance. The increased slope was almost a requisite as has been observed since that time. Lytle states that any slope less than piece rate is scarcely worth the trouble of figuring for the sake of incentive for high production. The high slope of piece rate plus the steps result in a generous incentive in comparison to other plans.

Perhaps the major disadvantage of the Merrick Plan lies in the calculations required in computing payment. These are more involved and laborious than for straight piece work. Another disadvantage is the nature of savings returned to the employee and whether they are justified one way or another.

4. Gantt's Task and Bonus Plan--Gantt's plan is in reality a combination of the time plan and the piece rate plan. (See Figure 8) It is similar to most contemporary plans in the respect of combination with the time plan guarantee, which is required by minimum wage laws. Gantt's plan adopts a time rate plan up to 100% efficiency. Upon

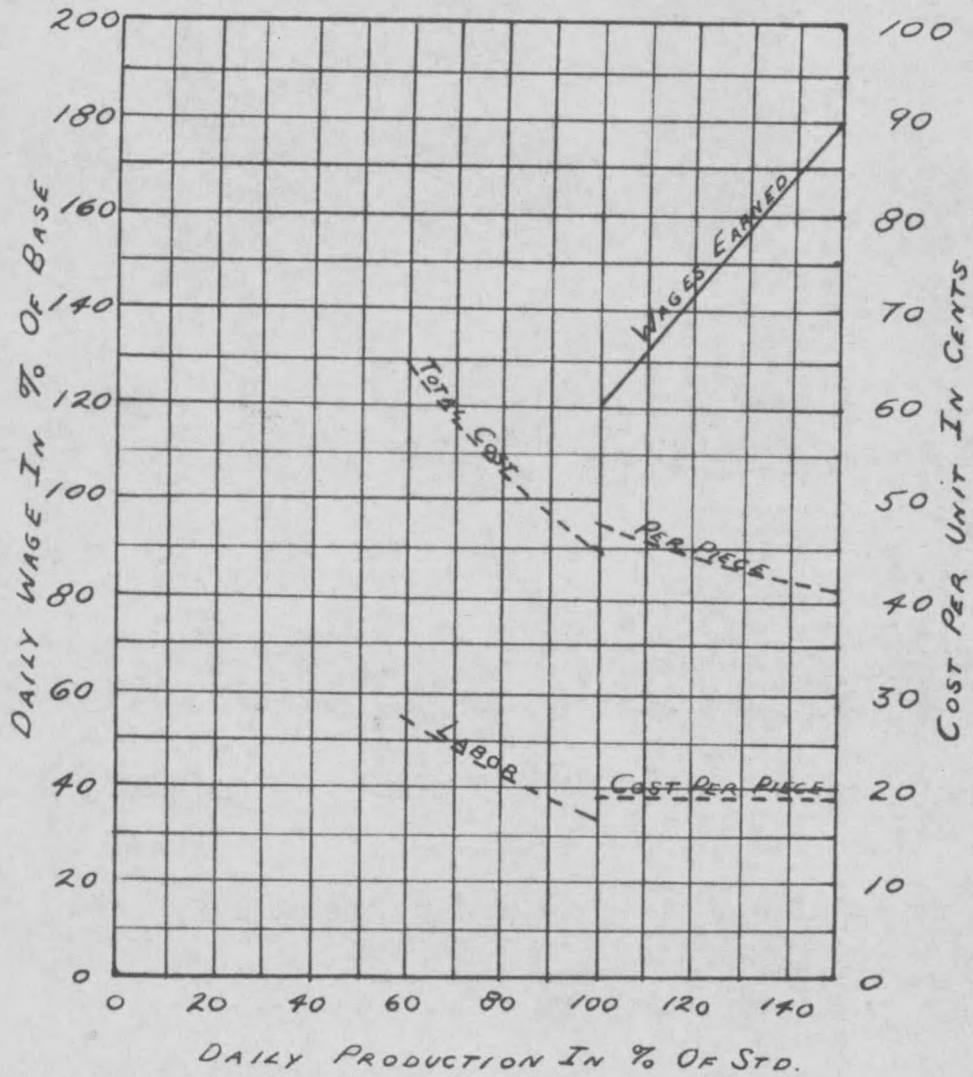


Figure 8
Gantt Task and Bonus Plan

reaching this figure a step bonus is given. This step bonus is shown as 20%, but in actuality varied considerably for various types of employee groups. Above that, earning is at the full piece rate slope (not the high piece rate).

Gantt did not let his plan stand alone, but emphasized the part management must play in achieving increased productivity. He went farther than Taylor in this respect and developed the concept of good "habits of industry", this being, of course, a counterpart of modern training programs. Supplementing the basic plan was also one for the foremen which encouraged them to provide a continuous supply of work to the men. Gantt continued to concentrate on management in his later years, and enlightening many managements through teaching to do their share in promoting greater productivity in their operations.

Costs of the Gantt plan are high for low efficiencies and low for high efficiencies. The plan tends to promote high efficiencies. Payment is calculated in terms of standard hours thus facilitating comparison between departments and even between plants.

A feature of the original plan was setting of the time rate below base. This was advantageous as far as cost and incentive considerations were concerned but it tended to make hiring difficult. Later versions of the plan generally

set the time rate at base.

5. Constant Sharing Plans--As the name implies, these plans allocate a constant share or a fixed percentage of the savings to the employee and a fixed share to the employer. This percentage is usually computed on the basis of direct labor savings, but could just as well be applied to total savings.

5(a). Halsey & Towne-Halsey Plan--Outstanding among the original constant sharing plans is the Halsey plan. It is a refinement of a plan developed by Henry Towne and is often called the Towne-Halsey Plan. (See Figure 9) Halsey's plan was based on historical productivity. If the workers exceeded a point of production set from past performances, they shared money value of the time saved with the company in some proportion (plotted as 50-50). The worker's return was paid at the standard hourly rate, thus returning to him only a portion of the direct labor savings. If the plan is started at a low efficiency level, payments can exceed those received under piece rate. This plan may be adapted for use with a standardized organization. However, it is rather ineffective at high levels of production. Naturally, employees would prefer to receive at least all of the direct results of their efforts as achieved by a high piece rate plan. This makes the Halsey plan obviously unattractive to

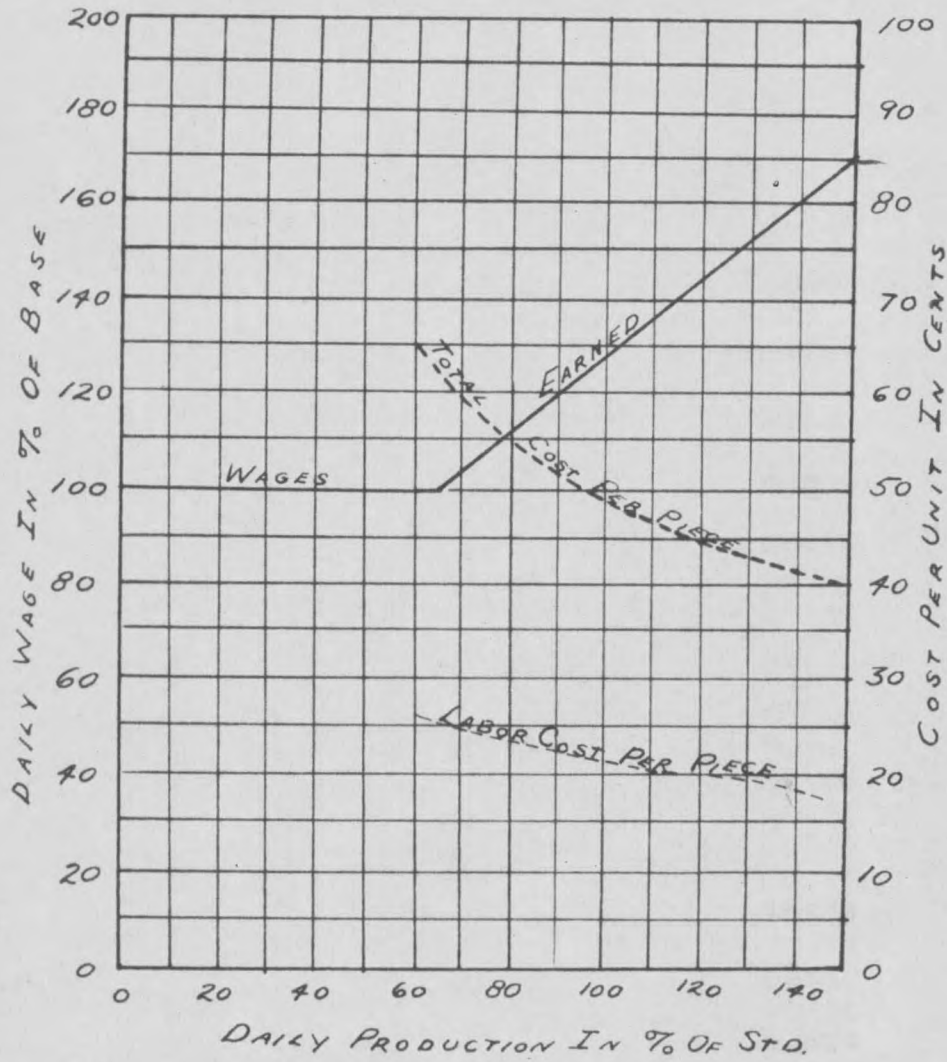


Figure 9
Halsey (50-50) Constant Sharing Plan

employees.

5(b). Bedeaux Plan--The Bedeaux plan (See Figure 10) is perhaps the most widely used of the constant sharing plans. Its curve of wages earned is similar to that of the Halsey Plan. The only difference from the Towne-Halsey plan is that the 50% feature was replaced by 75% and the task is higher. The plan in itself is not too original and with the task location for premium at high task it does not encourage too much effort on the part of the average employee. The outstanding feature of the plan, however, is its system of control. It is measured in terms of Bedeaux's or B's which are themselves a standard minute of work with all the allowances of time study included. In this feature it is one-sixtieth of the standard hour used in many time study plans. Determination of the "B" is made from a coefficient of rest (a fatigue factor) and the work elements of the allowance.

Standardization of reporting in terms of "B's" has facilitated comparison of departments and plants and thus becomes the basis for a production control system. Recapitulation sheets and clerical work added is considerable, estimated by Lytle (1942)₁ as five or six times that of other

1. Lytle, Charles W. 1942. WAGE INCENTIVE METHODS.
p. 226, Ronald Press, New York.

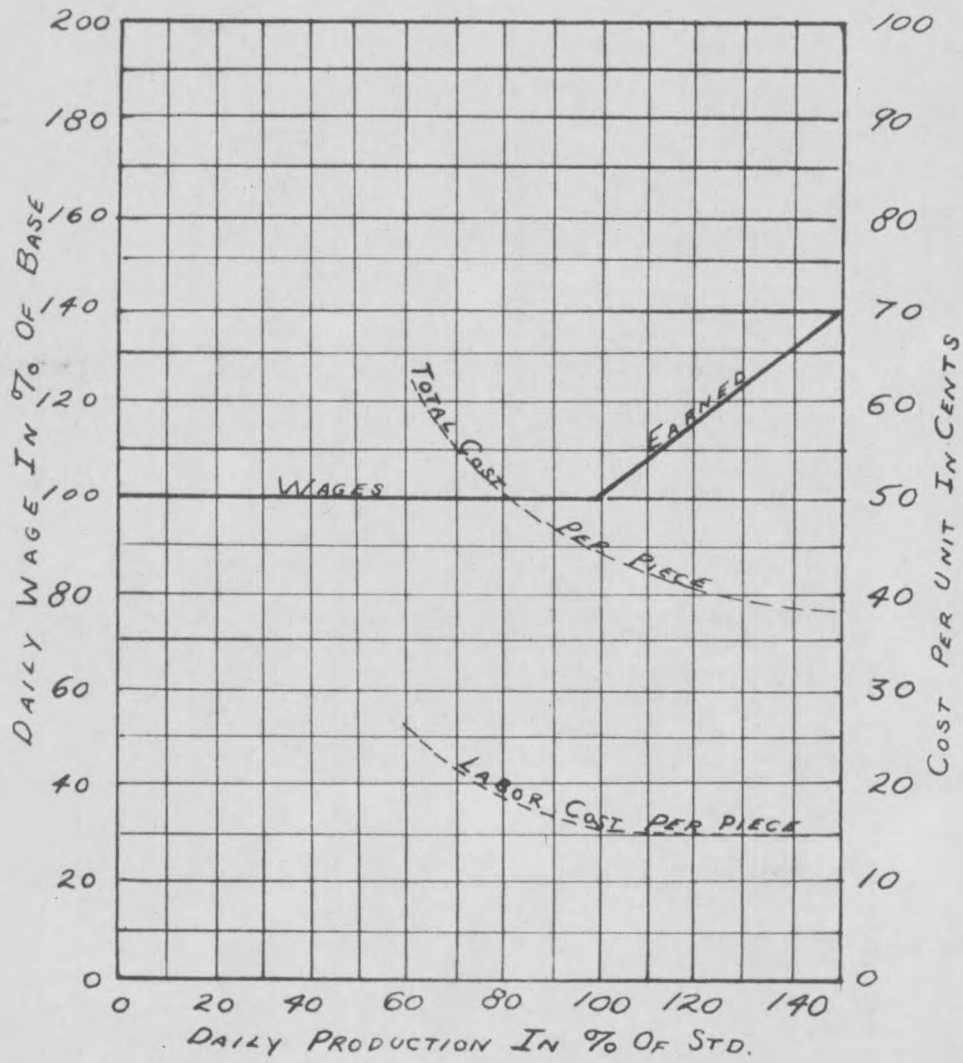


Figure 10
Original Bedeaux Point Plan (75-25)

incentive plans. The close control of operations which this realizes is supposed to achieve harmonious and active co-operation between supervisors and employees resulting in higher average earnings than would be achieved through piece work, despite the 75% return allowed. As with any time study system, the basic units, B's, may be used as a basis for distributing overhead in terms of direct labor hours expended or direct labor costs.

Objections to the Bedeaux plan centered largely around his system of superficial time study. Bedeaux engineers would merely watch an operator for a short time and then make a snap judgment of efficiency and apply that as a time study. Other objections were to various stretch-out methods employed by Bedeaux engineers in the textile industry and to inattention to plant standardization. Bedeaux developed a good production control system to accompany his incentive plan and thus automatically obtained management support often lacking in application of other incentive systems. However, his work in the field of methods improvement was sketchy and often neglected altogether. Such inattention and lack of insight often resulted in trouble at a later date with frequent discarding of Bedeaux plans.

6. Variable Sharing Plans--The variable sharing plans in reality eliminate the sharp increases in wages such as

caused by step bonuses or the transition from day rate to one of the constant sharing plans. (See Figure 11) They substitute such smooth curves as the arc of a circle or ellipse to the transition period between straight day work and the constant sharing feature or piece work. This enables a gradual transition to the high premium rates and lets the operator participate sooner in the results of his increased productivity. Naturally the plans also appear as various other curves as in the Barth plan which has a steep slope from zero production and tapers off to a more gradual rise at high task levels. The purposes are to give more encouragement to the operators and to avoid the sharp transition period.

The Emerson Efficiency-Bonus Plan is of the type which connects day rates and constant sharing plans. The transition period begins at low task and ends at high task with a 20% bonus. Above this point, the Emerson plan continues on at a basic piece rate slope rather than at the high piece rate slope represented at the (100,120) point. (See Figure 11) The greatest advantage of the Emerson plan is the gradual transition to the full premium. In reality, the earned wages curve of this plan could be designed to parallel the actual total savings curve and reflect a participation between employer and employee in terms of total savings.

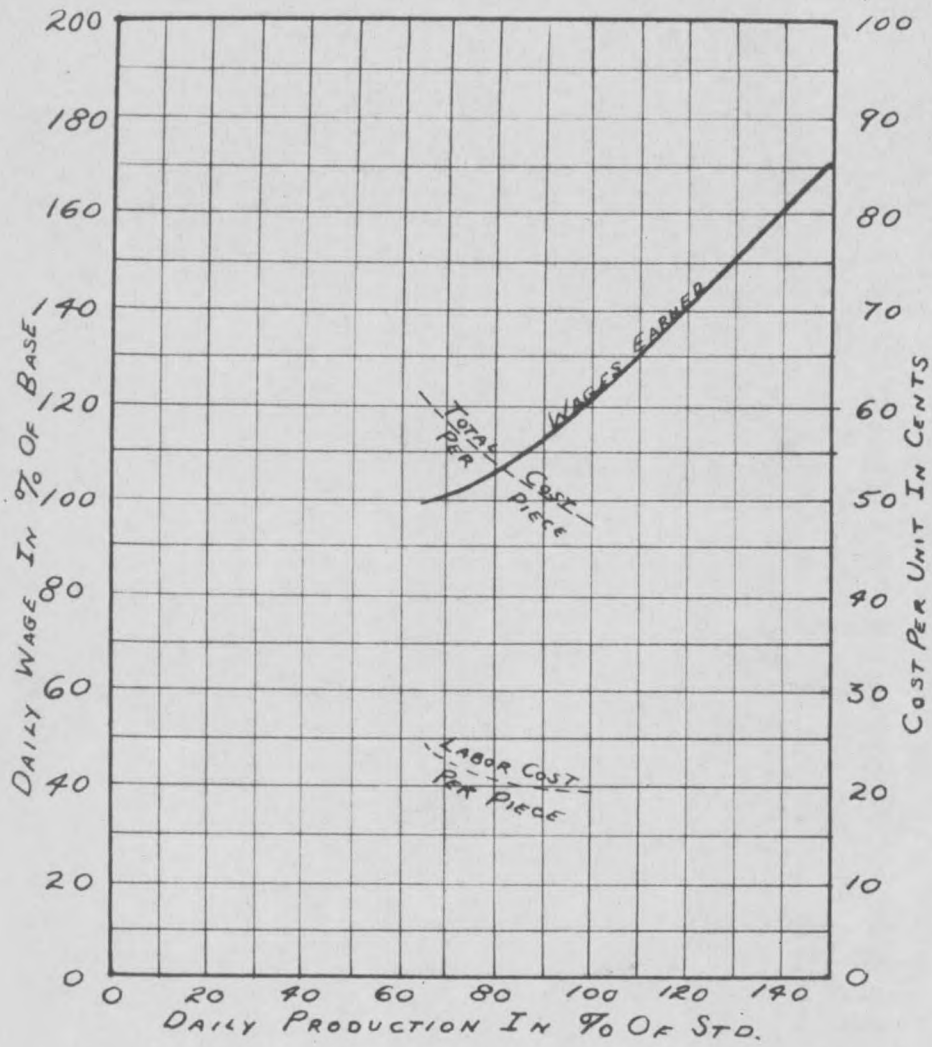


Figure 11
Emerson Efficiency-Bonus Plan

7. Accelerating Premium Plans--These plans are fairly recent developments and are designed to adapt to conditions brought about by the Fair Labor Standards Act of 1938.

The plans usually start at the legal minimum and use a portion of a conjugate hyperbola or parabola for the earning curve. Complexity of the plans and resulting difficulty in explanation to the workers retards the development of many of the plans based on such curves.

Admittedly all incentive plans have not been successful, many have been dismal failures. Various reasons are given to account for this. Soldan mentions primarily the following causes of such failures:

1. Incompetent industrial engineers applying rates and setting incentive payment.
2. Failure to standardize methods, equipment and procedures by management.
3. Lack of interest in incentives in the past by supervisors plus inadequate training on their part.
4. Failure to secure employee cooperation.
5. Attempts to cut rates.
6. Systems too complicated for the workers to understand.

Perhaps the most prevalent and potentially the most grievous mistake on the part of management is the failure to standardize. As emphasized in Chapter III, this can have a disastrous effect on rates and consequently on an incentive system. This is the typical instance where need for industrial engineering is overlooked by management. Workers are expected to provide all of the effort and skill required to

increase productivity, even when the latter is beyond their ken.

8. Application of Incentive Systems--Weak points in the incentive systems, as mentioned, are not as much the result of management oversight as they are evidence of poor or even fraudulent management. This combined with needless complication of incentive payment plans is also a hindrance to the cost accounting department, a detriment to operating procedures, and a frustration to the workers.

Rate cutting has attracted considerable attention in the past. As an out-and-out violation of ethics it is seldom practiced. However, unions and employees complain from time to time about managements' practice of reviewing rates when a job is redesigned. Evidently there has been some tendency on the part of the engineer to redesign so-called "loose" rate jobs with the purpose in mind of tightening the rates. Such revisions should not be made unless there is an obvious change in the job due to improved methods or changed conditions. Nothing can actually be said against management's desire to redesign "loose" jobs as these represent prime opportunities for methods improvement. Naturally an engineer will and should spend his time on a job where he can show the best results. He should remember the principle of "guaranteed" standards, however, and re-time

only the affected portions of the job. Theoretically, "loose" rates should not appear in the first place and their existence is often ignored as such by some managements. But, the combination of small increments of change and ignorance or gullibility of the time study engineer often cannot avoid proving the opposite to be true. In the opinion of E. J. Walsh (1953), Executive Secretary of the National Foundry Association, the company rests upon its reputation for fairness in such cases. He emphasizes this as follows:¹

"With regard to the question of rate cutting, let me say that most people in our industry agree that a rate once set should not be cut. In many instances a rate can be 'reviewed' in the event that a job is redesigned and the new design amounts to a new job. Even in such a situation the potential area of disagreement is rather great because one group might have an entirely different viewpoint than another on the question of whether a job is really different. In a case I know of where a loose rate was set and management decided to redesign because of this, the workers were quite dissatisfied and such dissatisfaction was justified. I do not feel that a set of guaranteed standards would answer this problem. I believe that any rate reviews-upward or downward-are potentially dangerous and only in the case where a company has established a history of fairness and consideration can a mutually satisfactory arrangement be made."

This is undoubtedly true in many cases where a history of fairness and honesty on the part of a company creates an understanding and a sense of mutual fair play on the part

1. Walsh, E. J. 1953. Letter to M. W. Burke dated January 15, 1953. National Foundry Association, Chicago.

of the employees and management. Equally important is the reputation established by the union. It is not unknown that union leaders have taken advantage of certain situations and used them as a leverage to obtain wages out of proportion to employees contribution.

A slightly different concern is exercised on the part of the time study engineer who must apply and maintain incentive rates. His difficulty is obtaining information which will enable him to maintain his rates on an up-to-date basis. The Timken-Detroit Axle Company is troubled, according to Charles Coleman, Chief Industrial Engineer (1953)₁, with rate administration by shop supervision. Reporting of changes in methods, machines, tooling and working conditions is often neglected by supervisors in the pressure for production. Costs are often neglected in the scramble for production.

In addition to the causes for failure listed above, there are several other important considerations involved in the administration of an incentive plan mainly:

1. Legislation.
 2. Union scales and union contracts.
 3. Going wages and wage differentials primarily in operation of the job evaluation phase.
 4. Standardization-as reviewed in the next chapter.
 5. Outline and maintenance of working conditions.
1. Coleman, Charles, Chief Industrial Engineer. 1953. Letter to M. W. Burke dated January 29, 1953. Timken-Detroit Axle Co., Detroit.

6. Maximum of incentive work per operator with a satisfactory earning opportunity.
7. Standards established by watch study should be delayed until operators are well-trained and of normal ability.
8. Retroactive features of incentives should be permissible.
9. Provision for new employees and shifting of old employees to new jobs.
10. Inclusion of supervisors and indirect workers.

These are considerations in addition to the preliminary steps to be taken before installation of a plan and are either aids or hindrances to the plan's operation.

Legislation is becoming of major importance in operation of incentive plans. These plans must be designed, if the employer is engaged in interstate commerce or is working on government contracts, to meet the federal minimum legal wage requirements. Various state laws are also in effect, notably in such states as Minnesota and Massachusetts. The majority of these regulations affect incentives only through the job evaluation or salary administration phases of the organization. Such items as union scales and wage differentials have a similar effect which frequently reflects the overall attractiveness of the base wage rates and therefore the incentive premiums.

Certain operating conditions and work environment often limit the incentive earning capacity of the employee. These conditions should be eliminated or improved wherever possible, e.g. by combination of job duties, providing sufficient

equipment and tools, etc. If the process or machine controls the operations in such a manner that the operator can only make 10% incentive regardless of his output, thought should be given to the possibility of an accelerated premium or an average incentive payment. Proper examination of the jobs in a particular department can eliminate the majority of these unfavorable conditions.

A continual change from incentive to non-incentive work has a deleterious effect upon employee morale. Peak productivity capacity is limited by such change as is the opportunity for maximum incentive payment.

Retroactive features for incentive programs are highly desirable for industries manufacturing large volumes of a large variety of similar products. The production of new models or new lines of equipment would ordinarily mean a big drop in productivity until incentive standards could be established. By making the payments retroactive, if so desired by the employee, all may enjoy the advantages of the incentive system much earlier.

Provision for learners or beginners is a problem usually handled by "transitory" incentive schemes which enable these people to enjoy incentive earnings in proportion to their effort and productivity. While they may not produce at a satisfactory level for an experienced operator, they should

be encouraged to become competent operators in as short a time as possible, meanwhile earning more for each increment of additional production.

This approach can well be broadened to include the design of the incentive plan itself. It should be set up to allow a sufficient spread between the guaranteed rate and the normal base rate to stimulate production. However, it must be remembered that Taylor's (1911) system failed because the spread, although very large, took place at too high a level of production for the average worker.

The National Metal Trades Association (1949), from its experience, substantiates the statements made in regard to incentive systems with this list of advantages and disadvantages of incentive plans:

ADVANTAGES:

1. Significant increases in production.
2. Substantial increases in employee earnings.
3. Noticeable reduction in production costs.
4. Improvement in cost control.
5. Personnel are more satisfied.
6. Less supervision is required.

DISADVANTAGES:

1. Difficulty of setting standards.
2. Dissatisfaction on the part of non-productive and daywork employees because opportunity for increased earnings is not usually provided.
3. Increased record keeping.
4. Poorer quality work and more scrap.
5. Difficulty of administering the plan.
6. Greater tool breakage and equipment depreciation.¹

1. National Metal Trades Association. 1949. INDUSTRIAL RELATIONS POLICIES AND PROCEDURES BULLETINS No. 3, Parts VI, VII, p. 11, Nat. Met. Trades Ass., Chicago.

Certainly there are disadvantages to these plans. It is management's task to eliminate the pitfalls and keep the increased costs to a minimum as they reflect back upon the return from the investment in such a plan. This investment is often considerable in terms of time and money spent on development and administration of the plan. The financial analysis of economic returns from a wage incentive plan should be in the form of a "break-even" chart. This should be supplemented by the publication of periodic reminders by the cost accounting departments showing current cost-profit relationships. Concentration on overhead expense considerations will then be emphasized.

Chapter III

STANDARDIZATION, PLANT LAYOUT AND MATERIALS HANDLING
AS ELEMENTS OF INCENTIVE MANAGEMENT

The whole concept of standardization is embodied in the fundamental Principle of Standardization. In that, "predetermined results, established procedures, and fixed types, sizes and characteristics of product improve operations and reduce the cost of manufacture."

The above principle as stated by Alford and Beatty (1951)¹ directs attention to the benefits to be derived from industrial standardization. These benefits are essentially those found in reduced manufacturing costs with consequently reduced prices, greater sales, and larger profits and wages. Standardization is essentially a management responsibility and prerogative. It is one of a series of functions which management must perform in order to obtain maximum productivity from the investment entrusted to it by the stockholders. It is a necessary accompaniment of incentive systems, whether financial or otherwise. Standardization paves the way for the worker to excel at his job.

Two necessary and very important phases of industrial standardization are those governing plant layout and materials handling equipment and procedures. Although in many

1. Alford, L. P. and Beatty, H. Russel. 1951. PRINCIPLES OF INDUSTRIAL MANAGEMENT. p. 256, Ronald Press Co., New York.

industries plant layout is continuously fluctuating, nevertheless those who institute the changes must adhere to the Principle of Standardization in order to attain optimum economies. Materials handling is also concerned with standardization of equipment and operating procedures, since they are directly connected with performance standards. The operators must obviously have material delivered and taken away on time if their standards are to be met. Application of time standards to the fields of plant layout and materials handling has been highly successful in establishing economical operating procedures together with better production control over the operations.

Standardization as a management-engineering activity has advanced to a position of considerable prominence in the last few years. Many companies have special standardization departments or groups. An example is given by this definition of the Standardization Section of the Methods Department at the Minneapolis Honeywell Regulator Company (1949):₁

"1.304 Standardization

This division is primarily a research and development group whose responsibility it is to constantly review and recommend changes in processes, tooling, machinery, and equipment to keep operations at maximum efficiency.

1. Minneapolis Honeywell Regulator Co. 1949. METHODS INSTRUCTIONS MANUAL
p. 2, Minneapolis Honeywell Regulator Co., Minneapolis.

The following general functions are included:

1. Develop manufacturing standards to be used by product designers, draftsmen, methods and time study engineers, tool designers, operating departments and inspection.
2. Conduct tool research and standardize tools.
3. Conduct machine and equipment research and standardize equipment.

The American Standards Association (1952) publishes a 30 page booklet which contains price lists of "American Standards." These are the best evidence of the fact that American managements are striving to do their share in achieving maximum productivity. No private organization, however, has a complete system of standards recorded in writing.

Standards used in industrial management are limited to those resulting from conscious decisions or those that are used repetitively. Reck (1954) points out that customs or habits that are called standards in the ordinary sense are not standards in terms of business standardization unless they are adapted by conscious administrative decisions.

Livingston (1949) emphasizes that control is one of the three principle tools of management. The others being system and leadership. To establish control, however, four actions are required, one of these being standardization. This means that the prime use of standardization is facilitating the use of the Principle of Exceptions, for it can be shown statistically that "Standardization reduces the probability

of variation.¹" This being done permits management to focus its attention on those items or procedures that cannot or should not be standardized.

Standardized procedures call for managements eye only when variation occurs as compared with the standard. Accomplishment is compared with the standard, or goal, if management control is effective. What does this mean to the worker? It means that manufacturing overhead is reduced with overall lessened costs of manufacture; that reliability is obtained by reducing variation and not through sheer human exertion.

Setting standards also means determining the amount of variation that will be permitted. This is amply demonstrated by the utility of techniques of statistical quality control with its range charts, acceptance sampling plans, and probability curves.

Bethel, et al (1945)², have defined a "standard" as a criterion of measurement, quality, performance or practice, established by custom, consent, or authority and used as a basis for comparison over a period of time. They postulate

1. Livingston, Robert T. 1949. THE ENGINEERING OF ORGANIZATION AND MANAGEMENT.
p. 194, McGraw Hill Book Co., New York.
2. Bethel, L. L., et al. 1945. INDUSTRIAL ORGANIZATION AND MANAGEMENT.
p. 182, McGraw Hill Book Co., New York.

that industrial standardization is (1) the setting of standards, (2) maintenance of standards and (3) coordination of the factors of production to comply with them.

Standardization is not to be confused with "simplification" which is concerned only with eliminating unnecessary variety and non-essential differences in the product. Simplification does not denote the technical and creative aspects that are evidenced by standardization. It is essentially commercial in nature.

Standards are primarily physical or personnel standards. Physical standards deal with engineering elements while personnel standards deal with people and the functions or duties of people.

Industry has adopted standards to a wide range of its activities. The result has been more efficient, more economical operation with less misunderstandings and mistakes. Attention to detail has been lessened, thereby freeing personnel for more important "decision making" or by providing better jobs for less able people. Examples of the scope of industrial standardization is found in the following list which shows various activities covered by standardization.

- | | |
|-----------------------|-----------------------------|
| 1. Quality | 2. Production |
| 3. Nomenclature | 4. Procedures & Methods |
| 5. Safety | 6. Dimensions & Proportions |
| 7. Oper. Instructions | 8. Specifications |
| 9. Forms and Reports | 10. Plant Layout |
| 11. Performance | 12. Cost Accounting |

What effect does standardization have on management and on incentive management in particular?

(A). Without standardization, there could not be equitably administered financial incentive system. Such a system is based on certain quantitative factors; such as standard operating methods, performance standards (as established by time standards), standard quality requirements, standard equipment and machinery, standard working conditions, and standard reporting and recording methods.

(B). Standard operating methods are essential to the individual receiving incentive payment as they tend to provide him with the best method management has been able to determine. The particular method has been established either by the test of time or through detailed study by industrial engineers. True, now and then individual workers can perfect better working methods, but generally this is the exception rather than the rule. Management standardizes a given method of operation because it is currently the best method available under the peculiar circumstance, and also is the one under which the employee will be timed and paid. It is in many cases the method which resulted from long and intensive research and development on the part of management. Modern management recruits and organizes teams of engineers and research personnel to establish the method.

(C). Quality requirements, machinery restrictions and the like also influence the method. Because of this it is essential that new and better methods be adopted as standard as soon as possible. Also, when manufacturing requirements are such that less expensive methods must be used to secure reduction in production costs, they should be established as standard as quickly as possible.

(D). Introduction of standards at the opportune period is of extreme importance. Bethel, et al (1945)¹, distinguish three periods in product or process development; namely, (1) the incipient period, (2) the development period, and (3) the saturation period. Reproduction of these periods in chart form is shown as Figure Number 12. Establishment of standards at any point on the progress-time curve causes a leveling off in the development process due to fixation of conditions. This means that effective standardization programs should not be introduced until the saturation period is reached. This is basic economics, as well as sound engineering and wise management. The institution of standards costs money as does the subsequent revision of premature standards. Thus such revision must be kept as small as possible.

The progress-time development curve shows unusually

1. Ibid. p. 187.

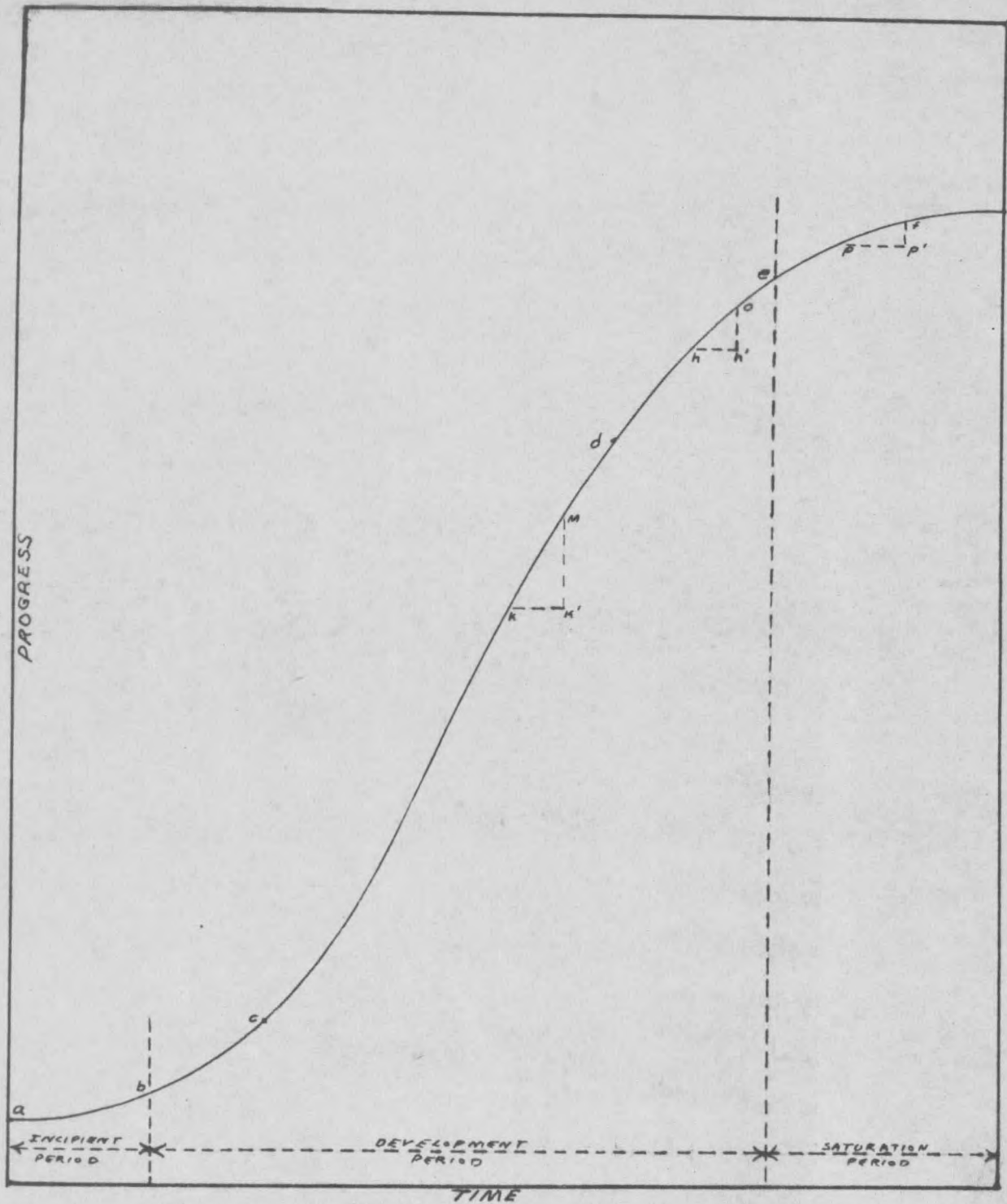


Figure 12
Progress-Time Curve

well one of the dangers of rigid standardization, that of retardation of progress. Institution of standardization before the saturation curve is reached could affect the company drastically. Henry Ford made this mistake with the Model T, "the car to end all cars." He standardized on it as the ultimate in automobile manufacture, and as a result fell far behind in his fight for supremacy in the field of automobile manufacture.

(E). Standards, however, are a boon to initiative when properly used. They liberate creativeness by reducing solved problems to routine and thereby freeing personnel for unsolved problems. Standardizing too soon or failure to revise standards when required, is usually the culprit, not the standards themselves.

Establishment of standards must be reviewed on an individual rather than an overall basis. For instance, a bracket for a tank control handle can be drilled on either an automatic drilling machine or an ordinary drill press. The automatic drilling machine is the more economical if production runs are consistently over 1,000 parts. Conditions may be such, however, that for the next two months the size of the "runs" will vary greatly from 100 to 2,000 pieces. This means that management would probably not standardize permanently on either method until production possibilities

are definitely forecast. This does not mean that a standard operating procedure cannot be set up for the method to be used for each run or that standard performance ratings cannot be set for them also. This merely illustrates that many methods, articles, forms and procedures in a particular manufacturing process can be standardized without waiting for some particular operation to be standardized. Standardization is a developmental process in itself which gets progressively more comprehensive as it goes along. In effect, it feeds upon itself. With one item standardized another may be. Engineering specifications are commonly developed in this manner.

(F). The relationship of standards of performance and incentives is very close. Performance standards directly determine the amount of financial incentive. They are a means of evaluating the results of any incentive program, financial or otherwise. Performance standards may be determined for management as well as for the individual employees. As such they reflect the success of incentives. For management and the employee performance standards may be recorded and directed through standard costs and budgeted costs.

(G). Livingston (1949)₁ emphasizes that "Success depends

1. Livingston, Robert. 1949. THE ENGINEERING OF ORGANIZATION AND MANAGEMENT.
p. 195, McGraw Hill Book Co., New York.

upon taking action before failure has occurred." This means that trends and tendencies must be discovered before becoming serious. By budgeting and a plan of action, management can analyze its commitments and means of meeting them, and then have an interpretive means by which results may be viewed in terms of overall plans. Thus, by establishing standard yardsticks management may evaluate its own progress and make corrections as needed to prevent re-occurrence of estimating errors or minimize the consequences of unforeseeable conditions. Efforts of management should be directed toward adopting the techniques of statistical quality control to management's programs. Too little of this has been done to date.

(H). The major criticism of standardization is its inflexibility as is the criticism of any mechanical system. Once standards are set, the tendency within the rank-and-file is to adopt the view that they must be met at all costs. This has brought about the establishment of a system to counterbalance these tendencies. Standard costs have been set up as an auxiliary control system to keep manufacturing costs on a competitive level.

Standard Costs:

Standard costs are not a distinct system of accounting. They may be used with the conventional job order or process

cost accounting systems. Furthermore, they are not limited to the so-called production divisions, but can and should be used for the sales and administrative branches of the business. Three important defects of conventional cost analysis methods are listed by Blocker (1950)₁ as: (1) the importance attributed to actual costs, (2) the historical aspect of the cost figures, and (3) the high cost of compiling actual costs. Without standard costs, no method is set up for measuring efficiency, insofar as the economic aspects are concerned, and the result is too great a reliance on misleading actual costs. Comparisons are made to actual costs not to what costs could and should be. These actual costs may be months old when in use and may represent costs of equipment already replaced or processes revised for some time. With an ordinary historical cost system it is not unusual for management to make cost estimates on new products which are based on operations a year previous. During a year, much in the way of plant improvements and additions or changes can be made. The other extreme is the case where cost estimates for new products, price lists, and bids must be formulated far in advance of actual production. Needless to say historical costs not yet realized are of no help. Finally standard

1. Blocker, John G. 1950. ESSENTIALS OF COST ACCOUNTING. p. 277, McGraw Hill Book Co., New York.

costs eliminate the use of detailed voluminous subsidiary records and the time and money consumed in keeping them up to date. This does not mean that actual costs should not be accumulated, for without actual costs to compare with, standards could no longer be considered a cost system. Differences between the two are handled by variance accounts when the books are closed. These variance accounts in themselves are the barometer of managements' efficiency in controlling the enterprise.

Standard costs are defined by Blocker (1950)¹ as "Pre-determined costs, based upon engineering specifications and representing highly efficient production for quantity standards and forecasts of future market trends for price standards, with a fixed amount expressed in dollars for material, labor, and overhead for an estimated quantity of production." Standards generally show estimates for each element of cost, for each production center, for each operation, and even for each machine. There are two classes of standard costs; price standards and quantity standards.

Price standards are based on forecasts of market prices for material, labor and indirect services and also upon quantity standards determined by engineering. As a result, budgets are necessary in the preparation of the price standards.

1. Ibid. p. 278.

These budgets are formulated by conferences of key representatives from the line and staff departments. Naturally, purchasing department representatives will generally be responsible for setting price standards for raw material and supplies. Industrial relations or personnel department representatives will generally advise on the future labor rates. Indirect overhead costs must be a combination of type and quantity estimates by line officials combined with top management decisions as to staff scope and functions. This would then be reduced to costs. For use in standard costs, these budgeted amounts are still considered to be estimates of what costs should be.

Overhead standards present two definite problems in formulation. First, the various overhead components must be estimated, and then the production estimates must be determined. The latter are the usual bases for distributing the overhead costs to the various cost centers. The most common methods of distributing overhead is in terms of direct labor hours, direct labor cost, or machine hours. Additional problems arise when the production of a plant fluctuates widely within a relatively short period of time. When this is the case, flexible budgets must be prepared. These will show estimated overhead for certain levels of production and establish distribution rates for use when the various

production volumes are realized.

Standard costs are also managements means for determining whether expected productivity levels are being met. Excessive operating costs, processes out of control, poor management, and poor rates of labor productivity readily stand out. The budgeted costs feature also focuses forcibly the lower echelons of management on efficiency and productivity. Waste is held to a minimum and tendencies toward waste can be caught before they become serious. Daily and weekly cost comparisons can easily be made that show management how it is doing almost immediately. Control achieved is directly proportional to the immediacy of return. With up to the minute reports supervisors are given an incentive to keep costs low.

As Caldwell (1953)¹ puts it so well, a cost system is used to tell what is going on in a department. He reiterates "If the company has the right kind of a cost system, it should enable him (the manager) to lay his finger on things he will have to work on in order to show results. The purpose of a cost system is not to give someone a job compiling figures, but to provide a yardstick against which to measure

1. Caldwell, J. W. 1953. THE IMPORTANCE OF ACCOUNTING IN INDUSTRIAL ENGINEERING.
p. 19, Journal of Ind. Engr., Vol. IV, No. 1, Feb. 1953.

results obtained by the department head."

Quality Standards:

Standards of quality are important in most industries today. Especially in view of the American economic system with its competitive spirit which is often expressed in terms of "more quality for your money." Quality standards are necessary as a limiting factor in the presence of production or performance standards. An incentive system would soon be undermined and rendered worthless if standards of quality were not established for the employee's production units. Even a simple drill press operation would be affected. Suppose an employee is drilling a $3/16$ " hole in a part while holding a plus or minus one thousandth's tolerance, which represents the quality standard. Without inspection or the establishment of a relationship between quality and production the employee would soon begin to force the drill through the hole with little attention to the drill condition. Within a relatively short time the company, and the worker eventually, would lose money because defective parts would have to be salvaged or scrapped.

Quality control techniques have been used for many years in an effort to enable the worker to maintain quality standards. Lacking in these techniques was the ability of an inspector or operator to predict what would be happening,

and as a consequence they could not make preventive adjustments until after a quantity of the product were ruined. The advent of statistical quality control in the past few years brought with it the ability to analyze measurements made of production quality performance and from these predict future performance. This has enabled the worker to maintain a high quality level by permitting him to make corrections before an operation was out of control. Management can therefore provide another service to the employee which will enable him to maintain a high level of effective productivity.

Alford and Bangs (1949) describe how standardized quality permits mass production along with its economies of production, distribution, and consumption (of raw materials in the latter case.) Opposing the forces operating toward mass production is the fact that no two articles are actually alike. This poses the need for determining standards of quality, which can be controlled. The method of controlling them is called quality control as previously stated. Quality control takes no direct action itself, it is only a means for determining and predicting poor quality. With the guidance of quality control techniques, management and the employees can make adjustments to keep their work within the quality range.

Inspection is the instrument through which most quality control methods obtain their data for analysis. Therefore, in inspection and quality control management has two complementary techniques to aid the worker in maintaining good quality. It must be remembered that incentive standards depend on quality standards. Most industrial operations can be speeded up at the sacrifice of quality. Human nature being what it is, employees will try to increase their productivity at the expense of quality if left to their own devices. Many financial incentive plans call for penalties whenever an employees' work falls below acceptable limits through his own fault. This technique must be handled with care to avoid penalizing workers for poor quality that is not due to their workmanship. Generally, grievance procedures handle the odd instances where this might happen.

Standard Equipment:

Standardization of equipment and machinery is necessary in varying degrees in our present day mass production industries. Production schedules demand prompt maintenance and repair of production equipment. This requires a stock of spare parts and supplies. If no attention were paid to standardization, large manufacturers would soon run out of warehouse space for storing spare parts. Quantity purchases of spare parts and supplies can be made with resulting

economies when standardization is practiced. Operators may be trained to operate several similar machines or only one machine instead of many. (This requires less skilled workmen.) Scheduling and programming of work is facilitated by reduction in complexity and variation in equipment. Production standards may be established in an economical manner when they may be set once for several machines. By choosing the correct machinery, management can obtain versatility without the added costs occasioned by variety in machinery and equipment. The importance of aggressiveness in machinery selection and operation should not be underestimated. Progress depends on constantly seeking new and better equipment, but not necessarily an indiscretion in selection.

Standard Working Conditions:

Standardized working conditions are at the core of a successful incentive system. Production standards are based on management's providing the workmen with uniform, safe, pleasant working conditions which are constant so far as work layout is concerned. Production will be affected through variation in working conditions, tools, methods, or equipment. A time standard is set up for one set of circumstances; if they vary, the standard should not be used and incentives cannot be paid until anew standard is set.

Working conditions should not be standardized "as is"

for incentive or standard setting purposes. As the "best method" is used as a basis for time study, so should the best attainable working conditions. Standard working conditions of different types can be taken into account by the time standards. Poor conditions are not permissible as they fluctuate too widely and affect production greatly. Unsafe conditions will cause the conscientious worker to go slow and rightly so. Accidents also affect morale; poor morale in turn affects production.

Standards should not be set and incentive payments cannot be made when working conditions are poor, non-standard, or are fluctuating continuously. Other incentive methods besides financial must be used if this situation cannot be improved.

Standard Reporting and Recording:

Standard reporting and recording methods have permitted standardization as we now know it. Especially in the field of cost accounting and standard costs have they become valuable cost reduction tools. Required conformity of thought and action is obtained as is assurance of proper recording and reporting of production performance and occurrences.

Mere standardization of reporting forms and methods is not enough. Forms control is necessary to insure that standardization occurs in a proper manner. Standardization

should not be attempted without exhaustive investigation of alternates. If this clearly points out the need, then the methods, forms procedures, etc. should be decided upon.

Even standardizing certain "signposts" is effective. Such items as headings at the tops of columns, report title locations, and subject locations can be prescribed and standardized as such. Time and money will be saved by eliminating the time wasted through mislocation or failure to locate these items where required and when. Reading from left to right is probably the outstanding example of such standardization in America today. Rolph (1954)₁ in discussing standardization of business reports, points out that "Headings at the top of columns in reports are signposts. If they are standardized and remain in the same places year after year, they enable us to become easily familiar with the shortest routes to each kind of information we want." His example shows how this form of standardization can be valuable in incentive management. Making the work easy for the employees and supervisors may enhance their desire to do their best.

Materials Standardization:

Materials standardization is generally a function of the

1. Rolph, S. W. 1954. THE STRONG CASE FOR STANDARDIZATION OF MODERN BUSINESS REPORTS.
p. 9, Adv. Mgmt., Vol. XIX, No. 3, March, 1954.

engineering and purchasing departments; together they determine the economics of buying various materials and for cost purposes standardize them. This reflects in benefits to the production worker earning financial incentives, since he is then guaranteed uniform, standard material with which to work and thus avoids interference with his work assignments.

Plant Layout as a Form of Standardization:

Plant layout is standardization. Not so much standardization of machinery, or work center locations, or material flow locations but standardization to achieve flexible plant layout. Flexibility is a prime requirement of manufacturing companies from small job lot enterprises to multi-million dollar corporations. Power sources, lighting, partitions, floor loadings, and overall building design should reflect this need. Plant layout problems are concerned with minimizing material and personnel movement. Reduction in the amount of time material spends in a plant, usually means overall cost reduction. Plant design should be engineered with these factors in mind.

Plant layout has been defined by Apple (1950)¹ as "Planning the path each component part of a product is to follow through

1. Apple, James M. 1950. PLANT LAYOUT AND MATERIALS HANDLING.
p. 3, Ronald Press, New York.

the plant, coordinating the paths of the various parts so that the manufacturing processes may be carried out in the most practical and economical manner, then preparing a scale drawing, or other representation of the arrangement, and finally seeing the plan is properly put into effect." To this might be added the function of forecasting future production layout change requirements, and in the case of new building design or changes, making provisions insofar as possible for such future changes. The writer's experience shows a good example of this in an overhead conveyor of a permanent nature proposed for hauling 500# rolls of paper from storage to printing presses. Such an installation would stagnate re-layout for new machinery or equipment. Materials handling equipment in this case would govern plant layout. This should be allowed to happen only when the economics of the situation clearly shows its necessity, or where no further expansion or modernization is possible or is remote, to say the least. Fork truck operation in this particular case appeared more logical as it could be handled on a part-time basis by other crews at a minimum of cost. Decision was also guided by the fact that further expansion and modernization was contemplated. Restrictions that would have been placed on any new layout by the overhead carrier were cause alone for its abandonment.

Apple (1949)₁ has enumerated the following types of plant layout problems:

1. Design change.
2. Enlarged department.
3. Reduced department.
4. Adding a new product.
5. Moving a department.
6. Adding a new department.
7. Planning a new plant.

To this list should be added an all important one, especially in the United States. Technological change calls for new equipment and machines which in turn creates materials handling problems. As such, it could include any one, several, or none of the above listed problems. Replacement of worn-out equipment is a similar problem, but usually not as complicated or as far reaching as technological change. Materials handling improvements themselves may be the result of technological change. The many multi-purpose machines developed of late illustrate the combination of production machinery and materials handling.

Technological changes are also related to changes occurring because of the nature of the product. Stable products must be handled in many cases in a much different manner than changing products in a firm. In conjunction with this is the volume of production to be forthcoming from the new product. This also limits the amount of money to be spent

1. Ibid, p. 4.

on the plant layout and materials handling equipment. Consider the case of the automobile industry which has the problems of technological change, unstable product design, and varying production quantities. Cunningham and Sherman (1951) illustrate still another factor 'rate of production' with the following statement concerning new models:¹

"The rate of production to be achieved is an important underlying factor (in making final decision concerning plant layout.) It guides the process engineer as well as the tool and equipment groups from the very beginning. It is the common denominator of all operations. Total volume anticipated may control the amount of money to be spent, but for proper balance of operations, the rate of production is controlling."

Within the situations of stable versus changing products, volume of production and rate of production, lie the eight problems of plant layout.

What are the objectives of plant layout? Assumedly they are to handle the problems listed above, but how and in what manner? Apple (1950)² has listed these objectives as:

1. Facilitate the manufacturing process.
2. Minimize materials handling.
3. Maintain flexibility of arrangement and operation.
4. Maintain high turnover of work-in-process.
5. Hold down investment in equipment.

1. Cunningham, Henry M. and Sherman, William F. 1951. PRODUCTION OF MOTOR VEHICLES. p. 59, McGraw Hill Book Co., New York.
2. Apple, James M. 1950. PLANT LAYOUT AND MATERIALS HANDLING. p. 6, Ronald Press Co., New York.

6. Make economical use of floor area.
7. Promote effective utilization of labor.
8. Provide for employee convenience and comfort in doing the work.

Above all, plant layout is one of the best management tools used in contributing to the productivity of capital investment and the productivity of the employees.

Two methods of plant layout for equipment arrangement deserve emphasis here. They are the process and the product (or line production) layouts.

In the process method, machines of a similar type for the performance of a similar kind of work are grouped in a particular area. For example all drill presses doing light drilling and burring work are located in the burring department.

In the product method, equipment and machines are located in order of the operations to be performed in processing a particular product. In this method, one department will have the machines necessary for doing a series of operations on a part, with the product moving e.g., from a lathe to a drill press to a broach, and so on.

Materials Handling Standards:

Materials handling is one of the highest component costs in the manufacture of a product. As such it deserves considerable attention on the part of management. Efficient materials handling is facilitated by good plant layout. This

means to the worker and to management that the manufacturing operations will be integrated in a proper and efficient manner. A maximum of productivity will be obtained only when materials handling methods and equipment are satisfactory.

Natwick, et al (1953) in describing materials handling list the following illustration:¹

"If a tree could be put into one end of a machine and a bale of paper bags, a carton of tissue or a roll of wrapping paper pulled from the other end, a large part of the materials handling now required in the paper industry could be eliminated, along with a sizable part of the cost of manufacture. Materials handling is always expensive. In some cases, it can be as much as a third of the direct labor cost of the manufactured product. One reason for this high ratio is that materials handling, unlike processing operations, adds nothing to the products value. It does not change the products' form."

It does provide one function, that of "place" utility. It places the material where it is needed.

Two factors are almost synonymous with materials handling. They are plant layout and materials handling equipment.

There are various manners by which materials can be handled. Briefly these are manhandling, mobile equipment, hoisting equipment, and conveyors. Mobile equipment covers a large field from hand trucks to various types of lift trucks, railroads, trucks and tractors. Hoisting equipment includes such items as elevators, derricks, cranes and hoists.

1. Natwick, Luch, Hallock. 1953. MAKING PAPER.
p. 451. Crown Zellerbach Corp., San Francisco.

Conveyors are of many types, primarily belt or screw conveyor modifications.

The function of this equipment is to facilitate the manufacturing process, reduce back breaking labor and get the material to the right place at the right time in as efficient a manner as possible. This is particularly important to the incentive worker who relies on having a sufficient quantity of raw material on hand at all times.

Plant Layout In Relation To Materials Handling:

Certain factors are important in determining plant layout in relation to materials handling equipment. These are:

1. The product: Without it there would be no plant. With it, certain machines are required, storage areas must be set up, and handling equipment provided. Generally, this must be adapted to the product.

2. Quantity of production: It has a definite effect on the economics of plant layout and materials handling. Low production usually means job lot manufacture with few specialized tools and equipment. High production brings with it special purpose equipment with large investments made possible by the economics of mass production.

3. Type of process: One product may usually be made in many ways. For example, paper can be made from pulp processed from at least three major processes: sulfate, sulfite

and mechanical grinding.

4. Machinery and equipment available for producing the product: Products are seldom produced on the ultimate in production equipment, therefore, modification in plant layout must be made for that which is or shortly will be available.

5. Plant location: The manufacturing plant may be located in an area with few storage facilities or in a climate with extreme temperatures. Storage and movement of materials will be affected by these. In connection with this are various safety regulations, building codes, underwriters restrictions, and the like.

6. Flexibility requirements: These, previously discussed, have a major overall affect on layout and handling problems.

7. Production planning: Lack of it can seriously affect layout. With poor planning more space is required and likewise more handling equipment.

The product, processing methods, and plant layout are extremely important in the production planning techniques of management. Therefore, production planning is the true core of plant layout. Products to be manufactured must be analyzed and worked into an overall production scheme. This usually means starting with a parts list or product list and routing each part or product. An assembly chart is helpful in some

industries to show inter-relationship among parts produced. After the routing is accomplished, a general flow diagram must be set up. Upon analysis and review it is detailed. Service and storage areas are also of great importance in some types of manufacture, and should be taken into consideration in the flow diagram and in the final master layout.

Various types of process charts, man and machine charts, time standards, and Gantt charts are valuable in completing the plant layout. The final layout should be arranged to facilitate the manufacturing process in the most economical manner, considering the various factors influencing the layout.

Summary:

Standards include not only standards of performance but standards in handling equipment, quality, production costs, in fact standards in all areas of production. Management must be familiar with these standards and apply them when and where practical. Mass production is made possible through standards as are high wages and low prices.

Chapter IV

JOB ANALYSIS & EVALUATION
AS A FOUNDATION FOR A WAGE INCENTIVE SYSTEM

Introduction and Definitions:

Wages and salaries represent the total standard of living or mode of life for the typical employee. The monthly or weekly check places a ceiling on his living standards and as such is of vital importance to him and his family. However, wages paid are not only a function of the work performed, they are also the result of working conditions, labor supply, variety and other intangibles of the job as a whole. As such they influence the wage scales in a particular company.

Due to the tremendous importance attached to wages in our economy, management must establish methods and techniques by which they can arrive at just and equitable wages needed to maintain worker morale and confidence in industrial leadership. These methods or techniques are usually systemitized as job analysis and job evaluation. These systems are managements' and in many cases the unions' answer to the question of establishing a fair and equitable wage structure. Without this logical approach, one factor in employee-employer relations takes on undesirable emphasis. It is the fact that employees tend to classify their own jobs. Consciously or sub-consciously they compare their job and the wages they receive against those of their fellow workers, against those

of workers in other companies, and of those in other fields of endeavor. With the limited data available to employees, the establishment of such a comparison system leads to grievances and morale suffers as a result. This is reflected in a lowered productivity of the affected workers. As a consequence, it is in management's interests that it adopt a system of job analysis and evaluation.

The problems which heighten management's and the union's interest in job evaluation are manifold. Without it, there is a lack of a uniform yardstick by which jobs in a company may be compared, and without a cohesive wage structure wage rate inequities exist. Jones (1948)₁ enumerates the following conditions as contributing to or causing wage inequities:

- "1. Lack of an adequate concept of the jobs' content, or poorly developed job descriptions (if job descriptions exist.)
2. Conscious or unconscious favoritism on the part of the responsible management representatives.
3. Poorly executed evaluation procedures.
4. Improper classification of employees.
5. Improper measurement of job performance.
6. Unequal pay for equal work."

Others, such as demotions or promotions without pay adjustments, seniority, physical handicaps, and differences in ability are worth mentioning. Such conditions must not prevail within the framework of an incentive system. They

1. Jones, Philip W. 1948. PRACTICAL JOB EVALUATION. p. 9, Wiley and Sons, New York.

can readily destroy the investment required to establish and maintain a program of incentive payment. A satisfactory wage structure soundly arrived at is the basis for successful incentive systems and well-grounded management of industry.

Low morale arising from a poor wage structure allowing irregularities or inequities will result in increased unit costs due to absenteeism, waste, lowered production, high rates of labor turnover and labor unrest. Successful management action in meeting production schedules, quoted costs, government regulations and union commitments will be hampered as a result.

A system of job evaluation cannot be set up merely by a system of qualitative job classification. The U. S. Dept. of Labor (1939) prepared the Dictionary of Occupational Titles which gives a foundation for such a classification system. The Dictionary established jobs and job groupings, called families, with which the individual jobs may be compared. Comparison is made possible by short job descriptions, included with each title, which identify and limit the title usage. This classification system does not accomplish nor does it attempt to accomplish job evaluation. No attempt at comparison between jobs is made, and generally no mention is made of the particular job's working conditions. Job evaluation

is rather a specialized type of classification in that it classifies jobs and types of jobs in relation to each other.

Just what is job analysis and evaluation? The U.S. Dept. of Labor (1944)₁ defines job analysis as: "The process of determining and reporting pertinent information relating to the nature of a specific job." Job analysis is the process of obtaining and recording job facts. Job evaluation is the entire process of determining relative job worth in comparison to other jobs in the organizational framework. It begins with job analysis, uses such techniques as job descriptions and job specifications, and then relates the jobs to a system which determines their relative value. Otis and Leukart (1948) stress the importance that is attached to the aspect of evaluation. They show that all factors must be evaluated within the framework of rating scales established for job evaluation. The value of job evaluation in measuring job worth for objective establishment of consistent wage rate differentials is also emphasized by Alford and Beatty (1951). They point out that job evaluation first establishes the difference between jobs, based on job requirements, and then through job rating followed by determination of the wage level converts this information into wage rates.

1. U.S. Dept. of Labor. 1944. TRAINING AND REFERENCE MANUAL FOR JOB ANALYSIS.
p.7, Government Printing Office, Washington.

Job evaluation fixes the basic wage in relation to duties. In conjunction with incentive payments it ensures that a worker is reimbursed in terms of his contribution to the manufacture of the product or products. The establishment of a satisfactory incentive program thus cannot depend on incentive payment methods alone. Without a satisfactory framework of job evaluation, incentive payments will be out-of-line as they would if time standards or the wage payment plan were incorrect. Thus, job evaluation besides being a method of managerial control is also one of the prime essentials of incentive systems.

Job Evaluation Systems:

The various types of job evaluation systems now in use by various companies throughout the country may be grouped into four major classifications. Otis and Leukart (1948)₁ advocate the classification approach set up by the War Manpower Commission. Their classification is as follows:

1. Non-quantitative evaluation measures.
 - a. The Ranking System.
 - b. The Job Classification System.
2. Quantitative evaluation measures.
 - a. The Point System.
 - b. The Factor-Comparison System.

Figure thirteen is a comparison of these four basic systems as reproduced from Otis and Leukart (1948)₁.

1. Otis, Jay L. and Leukart, Richard H. 1948. JOB EVALUATION p. 23, Prentice Hall, Inc., New York.

Figure thirteen presents the various job evaluation systems in a manner enabling easy comparison of the methods used in either case.

Bethel, Atwater, Smith and Stackman (1945) used a three-way classification into point systems, factor comparison methods and job-by-job comparison. Job-to-job comparison as identified by them is in reality the ranking system noted above. Scott, Clothier and Spriegel (1949) also advocate the latter system. They qualify this by identifying the point systems and the ranking systems as the primary ones. Jones (1948) in turn supports Otis and Leukart in their breakdown into a fourfold listing by combining the several systems into quantitative and non-quantitative groups.

The rational subdivision into quantitative and non-quantitative systems is undoubtedly the clearest manner of describing the systems now in use.

Non-Quantitative Systems--Ranking Systems:

The ranking methods are the simplest, most economical means by which management may use job evaluation. In its most elementary form, it is a card-sorting method. Each job is listed on a card with identifying information. The cards are then generally split into two groups, those rated highest in one, and the lowest in the other. Then again, these two are split up into groups of two each. The designated

Ranking System Classification System		Point System Factor Comparison System	
The Job Analysis: A narrative description of the job with the duties, responsibilities, degree of difficulty, and required qualifications clearly brought out.		The Job Analysis: A narrative statement of duties and qualifications. In addition, the job is broken down into the important compensable factors such as required experience and training, mental effort, and physical effort. The amount to which each factor is present in the job is indicated by a short narrative statement.	
Method of Relating Jobs: Jobs are ranked in their order of relative difficulty or value to the company, and grade levels are sometimes defined after the jobs have been ranked.	Method of Relating Jobs: Jobs are allocated to grade levels which are defined arbitrarily prior to evaluating jobs.	Method of Relating Jobs: Jobs are related by factorial analysis. A restricted number of fairly specific factors are selected for application to a limited number of types of work. The point values are predetermined before analysis of jobs and are decided arbitrarily, and the degree of each factor is expressed by a definition.	Method of Relating Jobs: Jobs are related by factorial comparison. The factors used are assumed to be fundamental to all jobs and of universal application, the point values are set after analysis of jobs from existing rates of "key" jobs, and the degrees of each factor are expressed by sample jobs.

COMPARISON OF THE FOUR BASIC SYSTEMS OF JOB EVALUATION

Figure number 13

procedure is continued until the jobs under consideration are effectively ranked. Ratings are usually arrived at by committee ranking or rating wherein a selected group of interested and qualified personnel collectively agree as to the relative placement of jobs. It is subject to considerable differences of opinion and as a consequence has certain shortcomings. Regardless, it is superior to no system, and it is the best known of the various job evaluation methods, according to Otis and Leukart, (1948). It is recommended particularly for small organizations or in those cases where some job evaluation system must be set up with dispatch.

Non-Quantitative Systems--Job Classification System:

The job classification system, sometimes called the grade description method, relies on predetermination of the grades or classes as a foundation. All jobs or positions are evaluated into grades or classes previously determined and already arranged in order of importance to the enterprise.

The first step in this system is to form a committee of individuals thoroughly acquainted with the various jobs in the organization. They establish the various grades levels on the basis of their determination of the existing and the possible number of levels of jobs. Next, all the jobs in the organization are then allocated to their proper position within these levels.

An outstanding example of this system is in the United States Civil Service which has adopted this system in its entirety for certain of its personnel. For its general service personnel, grades are established from GS-1, upwards. A graduate engineer for instance is classified as a GS-5. A graduate accountant usually receives the same rate as the engineer depending to some extent on the particular job he obtains. Each job is classified according to its own merits, by analyzing a position description, and then is assigned to the appropriate GS Grade. Specifications are given for the various position levels. By comparing the individual job against the specifications, the rating is established.

The job classification system is essentially a non-quantitative system and as such contains the faults attributable to these methods. Its major weakness as noted by Jones (1951) is the establishment of predetermined bench marks or classes of jobs. This necessarily falls back on past concepts of job values, and as such influences the evaluations. Jones (1951)₁ observes further that "experience in wage evaluation has proved that past concepts of values may approximate as many as 50% of the values finally determined." This means that deviations from past concepts would generally be considered as radical and would be rejected consciously or

1. Jones, Philip W. 1948. PRACTICAL JOB EVALUATION. p. 25, Wiley and Sons, New York.

or subconsciously. The job classification system has the advantage of speed and of being easily comprehended by those who must administer it. Lacking is the consideration of such conditions as physical effort, working conditions and mental effort. This makes possible similar classification of jobs with widely different requirements. An example from metal industry given by Jones (1951)₁ is as follows:

Classification	Description of work	Wage	
		Maximum	Minimum
21	Manual operations requiring knowledge of a limited number of operations. This includes filing and simple inspection; no tolerances, no written reports are necessary.	0.70	0.80

"It would be possible to group in one classification two extremely different jobs which still meet the specification of the bench marks. For instance:

SIMPLE ASSEMBLY OPERATION:

employee has excellent working conditions, few responsibilities, no hazards, light work.

FOUNDRY SHAKEOUT MAN: (foundry laborer)

typical foundry working conditions, hazards, heavy work."

This exemplifies the opposite extremes possible with such a system.

Quantitative Systems--Factor Comparison Method:

The factor comparison method is based on the framework of

certain key jobs in the organization. These jobs are analyzed in terms of basic factors, such as: mental requirements, skill requirements, physical effort, responsibility, and working conditions. The present wage rate for each job, e.g. in cents per hour, is allocated among the five factors proportionally to their estimated importance to the job in question. After all of the key jobs have their wages broken down, they are ranked, usually on a chart, in accordance with their assignments for each factor. The ranking is still in terms of cents per hour. The final job comparison is made by comparing each factor of the job in question in turn with the ranking assigned for that factor for the various key jobs. When the proper position is determined for the factor, its corresponding value in cents per hour is obtained from the chart. Values so obtained are added for all five factors to compute the wage rate for the job.

The advantage of this method is its accuracy and the relative simplicity of operation once the initial key factors are rated and allocated. Disagreements may be easily singled out, and upon arbitration on the one or several factors in question, may be negotiated readily.

Quantitative Systems--Point Systems:

A point system of job evaluation is also a quantitative system but differs from the factor-comparison method by separating

money from the job ratings. The point system relies on job facts rather than on job comparisons to set the value of a job. First each job is analyzed in detail, then, on the basis of the facts obtained, the job is measured by comparing the job facts with the gradations on a composite point scale. The scale is used then to set the point value of the job. Factor comparison differs from this procedure in that it merely compares one job against another job. Point systems are translated into monetary values by means of a separately prepared chart. Translation into wages may thus be established independently from the job evaluation plan which does not have to be changed with every change in wages.

Point evaluation systems require finding and selection of specific characteristics of work common to all jobs to be covered by the job evaluation system. Each characteristic must be considered as covering only one aspect of the job, and its degree is used in the final analysis to establish a relativity between jobs. This relativity may then be turned into wages. Each characteristic is thus an individual measuring stick for the job being analyzed. The separate evaluations for each characteristic are combined together to form a single point score for each job. This method requires the establishment of a series of rating scales, one for each of the factors which have been selected. A certain number of

points are allowed for each scale. According to the War Manpower Commission (1943)₁, the most common of the compensable factors which have been used in wage evaluation studies are:

1. Education.
2. Experience.
3. Initiative and ingenuity.
4. Physical demand.
5. Mental or visual demand.
6. Responsibility for equipment or process.
7. Responsibility for material or product.
8. Responsibility for safety of others.
9. Responsibility for work of others.
10. Working conditions.
11. Unavoidable hazards.

Otis and Leukart (1948)₂ bring out that the "point rating method is essentially a series of rating scales for the factors selected. Points are assigned depending upon the relative importance of the factors." This means that different jobs will have different ratings due to different values being assigned to their job characteristics against the various levels as set up in the point system.

The Kennecott Copper Corporation (1951)₃ uses a point

1. War Manpower Commission, Bureau of Manpower Utilization, Division of Occupational Analysis and Manning Tables. 1943. INFORMATIONAL MANUAL ON INDUSTRIAL JOB EVALUATION SYSTEMS. p. 15, Government Printing Office, Wash.
2. Otis, Jay L. and Leukart, Richard H. 1948. JOB EVALUATION p. 38, Prentice Hall, Inc., New York.
3. Kennecott Copper Corp., Utah Refinery, Utah Copper Div. 1951. UTAH REFINERY JOB EVALUATION PROGRAM. Kennecott Copper Corp., Salt Lake City, Utah.

system in their Utah Refinery. Their handbook evaluates each job in terms of twelve factors of job content. These factors are:

1. Pre-employment Training.
2. Employment Training and Experience.
3. Mental Skill.
4. Manual Skill.
5. Responsibility for Material.
6. Responsibility for Tools and Equipment.
7. Responsibility for Operations.
8. Responsibility for Safety of Others.
9. Mental Effort.
10. Physical Effort.
11. Surroundings.
12. Hazards.

This plan was designed for production and maintenance jobs below the rank of foreman, omitting clerical jobs. An example of their factor descriptions and point allowances is shown as Figures 14 and 15.

The descriptions and points are set up for each of the characteristics heretofore mentioned. This is not a "true" point system since it combines features of the non-quantitative systems. The procedure allows the use of bench-mark jobs which necessarily influence the ratings given. Specific instructions, however, are issued in this manual for classifications to be established regardless of existing wage rates. A comprehensive study of each job was made before the jobs were rated. The result of this study was a clear, concise, completed job description for each covered job. The ratings for the jobs were made on the basis of the information

PRE-EMPLOYMENT TRAINING--1

Consider the mentality required to absorb training and exercise judgment for the satisfactory performance of the job. This mentality may be the result of mature intelligence, and schooling or self-study.

Code	The job requires the mentality to learn to:	Numerical Class	Benchmark Jobs
A	Carry out simple verbal or written instructions necessary to the performance of a repetitive manual task. Make out simple reports such as crane reports and production cards. Operate simple machines and make simple adjustments where adjustments are limited. Use measuring devices such as scales, rules, gauges and charts in the performance of work where action to be taken is obvious. Operate powered mobile equipment performing simple tasks where little judgment is required.	Base	Pulling and charging man Stripper Stripper scrap man Casting crane follower Moule Blower Lift helper Copper Leaching helper Silver Refinery clean-up man Boilermaker helper Maintenance Janitor Maintenance Oiler

Figure 14
Sample Factor Description

Code	The job requires the mentality to learn to:	Numerical Class	Benchmark Jobs
B	Perform work of a non-repetitive or semirepetitive nature where judgment is required to obtain results. Lead or direct three or more helpers in a variety of simple tasks. Exercise judgment in the operation of powered mobile equipment servicing a number of units or performing a variety of tasks. Set up and operate machines or processes requiring a variety of adjustments. Post detailed data to standard forms or write reports based on observation or judgment.	.3	System man Pump man Tank house crane-man Loop machine man Nickel sulfate operator Pyrometer and set man Tractor operator Fusion kettle operator Truck driver Inspector
C	Make general repairs to equipment involving the knowledge of mechanical or electrical principles Interpret detailed assembly and complex part dwgs. such as involved in performing tradesmans duties. Direct the operation of a complex production unit which determines size, shape, analysis, or physical property of the product. Plan complex work details and procedures to obtain desired results	1.0	Furnaceman Mould Maker Parting man Boilermaker lay-out Machinist Machine man Boiler operator Weigher

Figure 15
Sample Factor Description (cont.)

contained in job descriptions.

The relative importance of the point systems is emphasized by Jones (1948)₁ when he says: "Evaluation methods based on some form of a point system have enjoyed so much popularity as to render the adoption of other methods almost negligible." He further emphasizes that the point system is gradually absorbing the best features of the other methods. His experience leads him to conclude that eventually, a combination of the best parts of the various approaches will become accepted as a standard job evaluation method in progressive industry.

Certain practical disadvantages of the point system are evident upon examination of the example. First of all it is difficult to construct. This means considerable expense is associated with setting up such a plan. This limits the use of this method to the larger or more financially capable companies, until the various trade associations, universities, research institutes and similar agencies can carry out the work begun by such organizations as the National Metal Trades Association and establish systems for smaller business units. Another disadvantage is purported to be the difficulty of explaining it to others. Concepts of relative

1. Jones, Phillip W. 1948. PRACTICAL JOB EVALUATION. p. 18, Wiley and Sons, New York.

weights of certain characteristics, point values, factors, and pricing the point values are difficult to explain. In addition, this is a lengthy process to date when all jobs in a large industrial unit must be analyzed and described.

The greatest advantages of this plan are its accuracy and independence from previous concepts or customs. Error is kept statistically to a minimum by subdividing the whole into its parts or characteristics. Also intentional or unintentional bias is easy to detect when each characteristic is pin-pointed. The guesswork inherent in non-quantitative plans is largely eliminated. Gone also is the reliance on previous estimates of job worth.

Designing A Job Evaluation System:

Certain considerations are necessary when a company first embarks on a job evaluation program. Management should first of all determine the scope of the system. Will it include all personnel, only the hourly personnel, or only the salaried personnel. This decision is important as it determines many of the methods that will be used and the limitations that must be imposed on the system. If the hourly personnel are to be included, provisions for union participation or approval must be included. Certain procedures must be set up in regards to methods of obtaining the information under these circumstances.

Who will do the Job? This is an all important consideration. Will an outside firm of management engineers be employed? Will job analysts obtain and classify all data and then set up the system, working under company officials? Or, will it be handled by a committee in conjunction with one of the afore mentioned groups? Advantages of each of these methods are peculiar to the particular company involved and the conditions under which the evaluation program must operate. Merits of the various methods should be reviewed in light of the particular circumstances. Financial limitations, personnel available or other restrictions will guide the final decision.

How will the information gathered be organized? Will comprehensive job descriptions and job specifications be written? They should, but economics of the whole situation must again be considered. Decision as to the method of job evaluation to be employed will in itself answer many of these questions.

Most of the systems demand that considerable attention and investigation be devoted to job characteristics to be used. These characteristics are the core of any job evaluation system, and must reflect accurately the qualities inherent in the jobs to be rated. Characteristics obviously do not have the same degree of importance in diverse jobs.

This calls for "weighing" of characteristics to establish the proper relationship.

The final step in the preparatory stage is to develop a job evaluation manual which will contain the decisions made and practices to be followed when instituting the system and in administering it. Proper consideration should be given to standardization here, as this point can and should be the stage of utmost standardization. If possible, job titles should be made to conform to the Dictionary of Occupational Titles published by the U. S. Dept of Labor (1939), or at a minimum the jobs should be cross-referenced with the Dictionary.

Administration of a job evaluation system ties in closely with that of a wage incentive system. Collective bargaining is also of prime importance in both. Agreements made with respect to one will affect the other. Unwise agreements could conceivably undermine the administration of either system. Likewise, motion and time study is often used in job evaluation, for careful determination of point or ranking to be allowed certain jobs.

In a final analysis, the wage ratios as determined by job evaluation will form a foundation for determining the wages paid under an incentive system. It is a framework about which wages will fluctuate. The particular features of an

incentive plan will make possible only a range of percentage payments which will be grouped around the concept of a normal operator. Job evaluation will establish each individual job's relative importance in the wage structure. Collective bargaining, however, should set the wage rate which will transform the two programs into actual wages for the employee. Job evaluation and financial incentive programs will thus be separated from the actual wage determinations. As a consequence, wage negotiations will not disturb the framework of these programs. Corrections that are necessary should be separated from the wage negotiations and evaluated independently. In some instances, management may be forced to alter certain wage rates due to current labor market conditions. This should be an acknowledged temporary measure, and any payment so made should be treated in a separated category. Notations similar to those made for overtime can satisfactorily handle this.

Economic conditions will affect wage rates from time to time. Recognition is made of this fact by the U. S. Civil Service Commission (1945)₁ by the following remarks regarding pay determination: "Certain economic factors should also be considered, such as (1) recent changes in cost of

1. U. S. Civil Service Commission. 1945. POSITION CLASSIFICATION AS AN AID TO SUPERVISION. p. 6, Government Printing Office, Washington.

living-----." Cost of living adjustments similar to those instituted during World War II can be made to handle a temporary situation of this kind.

Of extreme importance is the attractiveness of a job to the worker. This feature should be included among the characteristics of a job evaluation system. If not as a separate category, characteristics such as working conditions should be so described as to include the attractiveness or lack of it in a particular job. This is covered to some extent by the U. S. Department of Labor (1950) when they advise the job analyst to determine why a man does a job.

Job evaluation is a valuable management control technique. It again makes possible management by exception. Upon establishment of a job evaluation plan, fixing of individual base rates becomes an exception rather than a rule. Management may concentrate its attention in this field to those areas needing its attention without "straining its arteries" so to speak. Inequalities in the wage structure are removed in a manner never possible with collective bargaining or arbitration on an individual basis for each group of jobs.

Otis and Leukart (1948)₁ list four general areas of control available to management through job evaluation. These

1. Otis, Jay L. and Leukart, Richard H. 1948. JOB EVALUATION.
p. 420, Prentice Hall, Inc., New York.

are:

- "1. Keeping rates in line with the structure.
2. Prevention of pay inequity.
3. Control within rate ranges.
4. Control of related personnel functions."

Item four perhaps needs some clarification. The job evaluation system through its comprehensive analysis and synthesis of job content provides the material, in suitable form, for establishing promotion ladders, identifying employee selection requisites, and permitting rational transfer and training.

Control of wages and salaries is accomplished by both the union (if any) and management. Job evaluation can be used with as much effect by the union as by management. An example of this is evidenced in the techniques of the "Minneapolis Federation of Honeywell Engineers"¹ in their annual wage survey which is used as a basis for wage demands. An actual wage survey is made each year wherein employers throughout the country or their unions are contacted and jobs in these companies evaluated by job evaluation and then compared to Honeywell's wage rates.

Emphasis should be placed on objectivity and fairness of job evaluation to the firm and the employee. Each job must be analyzed on the same basis and the inequities of a haphazard

1. Minneapolis Federation of Honeywell Engineers. ANNUAL WAGE SURVEY.
Minneapolis Federation of Honeywell Engineers, Minneapolis.

system must be avoided. Job evaluation is a tool for proper distribution of the wage dollar, and as such calls for greater understanding of its operation by both the management and the worker for their mutual good.

Chapter V

MOTION AND TIME STUDY
AS THE FOUNDATION FOR A QUANTITATIVE INCENTIVE SYSTEM

Motion and time study as a scientific tool of industrial management is finding ever wider use in the majority of industries. There is a limit to it's usefulness, but primarily because of the nature of man himself rather than by restrictions imposed by manufacturing conditions. In some few cases where labor cost is a small portion of the total manufacturing cost, motion and time study is not economical or is so unwieldy as to cause its merits to be undermined.

Industrial management to be effective, must know what is happening, what should be happening, and what is going to happen in the future. Motion and time study can supply basic quantitative information which will serve as a foundation for the answers to these questions. Primarily, this is attained through the predictive capacity inherent in the scientific method and through analytical methods provided by motion and time study. Often, the detailed records of past performance are in themselves a source of what has been happening, from which comparisons may be made with what is happening. The ability of management to make decisions is obviously enhanced by such factual knowledge, but it is strengthened immeasurably by being able to predict future performance. In conjunction with the other areas of industrial engineering,

motion and time study permits management to alter conditions so as to create a more favorable environment for efficient operations and meanwhile facilitate progress.

Rautenstrauch (1941)₁ in discussing integration of processing operations through plant layout to obtain continuity of flow in manufacture demonstrates that there are only three primary considerations:

1. Timing.
2. Reservoir effects.
3. By-passing.

It is axiomatic that in order to perform the whole sequence of operations in the shortest time, they must naturally be integrated as to time. This means using the methodology of motion and time study a detailed analysis must be made of each operation to be performed whether it is processing, materials handling, or storage. Rautenstrauch (1941)₂ reiterates that "In fact the success of the whole scheme of continuous manufacture depends on proper timing. Reservoir effects and by-passing provisions merely provide for either economy in manufacturing operations or for temporary stalling of the production machine. Without proper timing modern assembly manufacture as illustrated by the automobile companies would be impossible."

1. Rautenstrauch, Walter. 1941. THE DESIGN OF MANUFACTURING ENTERPRISES.
p. 226, Pitman Publishing Corp., New York.
2. Ibid.

Although motion and time study is important under all manufacturing conditions, in particular the modern mass-production industrial plant must be designed around it as a central integrating factor. The primary object according to Rautenstrauch (1941)₁ in planning the industrial plant is to arrange and house the machinery and materials of manufacture with:

1. Minimum fixed charges.
2. Minimum time in the flow of materials through the plant.
3. Minimum number of employees.
4. All in relation to maximum output of specific quality products.

Although, to attain integration, these items should not be considered independently, for emphasis, it must be said that the time element is of the first importance. It controls the other three and is the "tail that wags the dog." However, this very important tail can be made to "wag" correctly through detailed investigation and study.

Motion and time study may be defined briefly as a systematic method for determining efficient work procedures and for determining the quantity of work which should be done by following the prescribed procedures. Originally motion study was thought of as being separate from time study, however, they are basically one inseparable process aimed at determining

1. Ibid, p. 233.

the proper man and/or machine time allowance for a particular job, task, or operation. Proper time allowance means the best method with the proper time for such a method. Motion study analyzes the given operation to determine work methods, work layout, and working conditions. The Gilbreths (1917)₁ originally defined motion study as follows:

"Motion Study consists of dividing work into the most fundamental elements possible; studying these elements separately, and in relation to one another; and from these studied elements, when time, building methods of least waste."

Today, for example, Alford and Beatty (1951)₂ define time study as:

"A searching scientific analysis of methods and equipment used or planned in doing a piece of work, development in practical detail of the best way of doing it, and determination of the time required."

This is simply stating the Gilbreths' definition of motion study in a different manner. Actually, contemporary time study is accomplished in the same manner as motion study but with more detail and less scope. Time study may be said to further analyze the subject operation in minute detail by observing individual movements as identified by motion study in conjunction with the times taken for these movements.

1. Gilbreth, F. B. and L. M. 1917. APPLIED MOTION STUDY. p. 43, Sturgis and Walton Co., New York.
2. Alford, L. P. and Beatty, H. R. 1951. PRINCIPLES OF INDUSTRIAL MANAGEMENT. p. 471, Ronald Press Co., New York.

From these fundamental data, time study determines the job procedure, keeping in mind the tenets of human engineering. For optimum results, motion study is inseparable from time study. Also, together they are not separable from efficient management wherever conditions are such as to permit their use.

"Work simplification" is the application of motion and time study to the areas of "process" and "operation" analysis. It uses in addition to basic time study equipment such aids as flow process charts, man and machine charts, and operator charts. Work simplification is merely an expansion of the field of motion and time study and need not be treated separately.

Because of its nature, motion and time study is the coordinating function and medium in mass production industries. Livingston (1949)¹ shows that "organization" implies the best possible design of all the units combined rather than the best possible design of all the units individually. Therefore, organization includes coordination. Stated simple "Coordination is that which makes organization good."

Procedures And Methods As Foundations For Incentive Management:

Standardizing The Operations:

The first step in motion and time study is to standardize

1. Livingston, R. T. 1949. THE ENGINEERING OF ORGANIZATION AND MANAGEMENT.
p. 169, McGraw Hill Book Co., New York.

the operation. This may be done in a final sense only after completion of the time study if "observational" methods are used. For the purposes of this thesis, the observational method will be taken as normal practice with the "standard data" system treated separately. Standardization as such has been defined in chapter III.

To standardize any given operation, the process as a whole must be studied to determine the effect of the process on the individual operation. Also to be taken into consideration is the cost of improvement a given operation can afford to bear. Not every job will warrant all the refinements that motion and time study have to offer. With these considerations in the time study engineer's mind, he analyzes the operation. After analyzing the work, he synthesizes it into standard operation details for which the time standards are set.

Certain considerations are basic to the whole motion and time study process. They are actually steps in an intellectual process as follows:

1. Obtaining, reviewing, and recording all pertinent information concerning the job to be studied.
2. The supervisor of the department concerned should be contacted to enable him to prepare for the study if such is required.
3. Inform the operator that his operation is to be studied.
4. Standardizing the method as previously mentioned.
5. Taking the time study and establishing the standard.
6. Publishing the standard by describing in detail the operation and how it should be done along with the time allowance. This should include information as to tools

and equipment to be used by the operator in performing the operation.

7. Reviewing the study when required.

The exact procedure for making a time study will vary considerably depending upon the industry and the type of operation to be studied. Considerable attention will need to be given to the organizational structure of the particular company. The time study engineer is usually associated with a staff department and as such is dependent on the line officials for permission to study an operation. These officials should not be allowed to govern the methods used in arriving at the time standards as long as such procedures do not affect employee relations or are contrary to accepted work methods, or in the rare case, they disrupt work schedules. The line official can and should prepare for the forthcoming time study by preparing the operator for such a study and establishing a contact for the time study engineer. The operation should be running satisfactorily before a study is made. This is the line supervisors' responsibility. This is of the utmost importance as standards should not be set during the developmental stage or in the experimental stage of manufacture. Nor should data be taken under abnormal conditions which will affect the reliability of the standard. This is a necessary requisite since time standards once established must be treated

as the name implies and not be subject to change, except under unusual circumstances. The majority of companies now guarantee their standards. The operator must be assured that changes in standards will not be attempted unless there are changes in methods or in job conditions. Past experience has shown the downfall of many incentive systems₁ that were based on out-of-date time standards and standards that were not guaranteed. This necessarily implies that working conditions should be normal when establishing the standard. It is the supervisor's responsibility, again, to keep the time study engineer informed of changes that may effect time standards in his department. This should not be left to chance. Some procedure must be set up for approving all methods changes. The notation of such changes should be routed to the time standards department where the job is either taken off standard or a new standard is established if need be. This control device is vital to the success of a "time standard" system. Out-of-date standards are devastating to the morale of employees and therefore to the production of a plant.

Analysis Into Elements:

Taking the time study calls for certain detailed procedures in addition to those described above. First, the

1. Substantiated in a letter to M. W. Burke, dated March 19, 1953, from John E. Brennan, Jr., Chief Standards Engineer, Yale & Towne Mfg. Co.

given operation should be divided into a chronological series of elements, and a complete description of each element should be recorded. These elements should be established so that they are the natural subdivisions of the operations that are easily noticed by the engineer during the study. As an example of an element would be the task of removing a part from a jib or fixture. Setting the part on the table would be another. Drilling a hole in a part would be still another element. These would be natural subdivisions of a drilling operation on a drill press. Such a breakdown provides for future changes in operation detail and permits guaranteed standard elements. When a methods change occurs, the entire operation need not be retimed, only the affected elements. Reading points should be established. These are the incidents that determine the end of each element and permit the analyst to subdivide the operation time into individual times for each element by reading his stop watch at each "reading point" in the cycle. The "reading point" for "setting the part on the table" would be--release part. Greater accuracy is obtained by this method as the individual times may be averaged and then added together. This method also permits the deletion of elements purposely or accidentally introduced by the operator but which have not contributed to the work.

Extraneous Elements:

The time study engineer must also remember that in many cases being timed is a challenge to some operators. They try their best to confuse the engineer and as a consequence obtain the best possible time as far as they themselves as individuals are concerned. Also, being timed may antagonize some workers and they will do their best to thwart the engineer's study. The engineer should recognize that many workers are unalterably and even irrationally opposed to time study and will do their best to invalidate it by introducing foreign movements. These extraneous elements must be deleted from the operation.

Observational Methods:

Observing the times for the individual elements is usually done with a stop watch. However, motion picture cameras, marstochrons, and other devices are also used quite frequently. The more expensive methods are justified only in special cases; usually only when analyzing operations in detail or for gathering elemental data for establishing standard data systems of time study.

The number of cycles to be timed varies with the particular operation. Individual judgment is necessary to determine the economical and satisfactory data. Statistics can be used in determining the number of cycles to be timed; but, this usually means analyzing the data first and using various

sampling techniques which in themselves often take more time than timing the additional cycles would take.

Leveling of Raw Data:

Upon observing and recording the time taken by a particular operator in the performance of an operation, the engineer's next step is to "level" his times. Leveling is a term used to describe the procedure used to convert the actual time observed to that time required for a normal operator. This is also called "effective performance rating." The factor used to rate an operator is expressed as a percentage in comparison to 100% as normal. It is based chiefly on the engineer's judgment of the operators performance. The engineer, therefore, must be trained at some length through actual re-timing of timed operations. His judgment can be further developed by working with "rating" training films available from various sources, thus enabling him to standardize his concept of a normal operator with that of the accepted professional standard. Progressive companies have done this work for some time and have developed their own rating films.

The leveling concept and practice recognize the difference in performance output between different operators, and between performances of other operators on different occasions. Leveling permits the better than normal operator to be rated as well as the sub-normal operator. This concept of the "normal

operator" should be differentiated clearly from that of the average operator who will vary from time-to-time depending upon labor supply and average experience of the operators.

Several techniques of leveling are used in industry. In one, speed or tempo alone is measured. In the other, skill is also measured. Users of the speed rating technique maintain that skill is a necessary component of speed and it is not necessary to rate skill. They claim that skill is the result of a superior method and that skill as a consequence is speed or ability expressed in terms of speed.

Both systems of rating rely on the idea of a "normal" operator. Barnes (1949)₁ demonstrates that this "normal" operator's speed may be compared to:

- "1. Walking on the level at the rate of 3 miles per hour.
2. Dealing a deck of 52 cards into 4 equal piles in 0.50 minutes using the following standard method. A person seated at a table holds the deck of 52 cards in his left hand, and the top card is positioned with the thumb and index finger of the left hand. The right hand grasps the positioned card, carries and tosses it onto the table. The four piles are arranged on the four corners of a one-foot square. The only requirement is that the cards shall all be face down and that each of the four piles shall be separate from the others.
3. Filling a standard pin board with 30 pins in 0.41 minutes, using the two-handed method.

Leveling or rating an operators performance is the factor most often disputed by the union when objecting to a standard.

1. Barnes, R. M. 1949. MOTION AND TIME STUDY.
p. 358, Wiley and Sons, New York.

However, it has been shown time and again that an operator may be rated to within 5% of his actual performance by an engineer if the operator is working between 75% and 125% of normal.¹ Beyond this range the ability of the engineer to accurately rate the operator is today in question.

Upon completion of the leveling procedure, the engineer must credit the operation with certain standard allowances which should be established for such intermittent elements as: interruptions for parts inspections, convenient setting of the parts supply, tooling changes, personal time, and fatigue. Times for many of these elements should be established by "ratio-delay" study as it is the most economical method of determining the correct overage time of a widely varying activity.

Ratio-Delay Study:

Ratio-delay study adopts the statistical technique of random sampling for the solution of certain time study problems. This technique is being increasingly used because of the ease and reliability of the information obtained. In effect, this technique simply means that the engineer or supervisor, as the case may be, merely records at random intervals the status of the given worker or machine. By taking a sufficiently large number of observations at random, the percentage of readings taken for each task or delay, as the case

1. Experience of author at Minneapolis-Honeywell, 1951.

may be, gives him an estimate of the true proportion of the total time taken by the activity under observation. Rules governing such ratio delay techniques are substantially the same as those applying to any random sampling plan. Errors can be introduced and false assumptions obtained by using non-homogeneous groups, taking an inadequate number of readings taking the random samples over too short a period of time, or the abandonment of the random feature of the system. The outstanding advantage of the system is the cost. Alford and Bangs (1949)¹ state that the cost of ratio-delay studies is about one-third that of the typical production studies.

Obtaining Operator Cooperation:

Introducing the time standard to the operator should be the responsibility of the foreman as he is responsible for enforcing the standards so determined. The engineer should first review the standards with the foreman, who will then be able to explain them to the workers. It is the foreman's duty to check the study, not for accuracy but for conformance of job conditions and methods with standard shop practice. Occasionally the novice engineer originates a "brilliant" new method which won't work in practice. Deviations from standard practice should be examined by the foreman and

1. Alford, I. P. and Bangs, J. R. 1949. PRODUCTION HANDBOOK. p. 519, Ronald Press, New York.

obtain his approval. Allowances for inspection and tooling changes are subject to the supervisors review and must be in conformance with the specifications and quality control for manufacture of the article.

Place Of Time Study In An Industrial Organization:

The effectiveness of the time study engineer is governed by his position in the organization and by that of his department. Carroll (1938)₁ has advocated positioning the standards department or the time study department under the controller. This means placing an engineering or at the very least a technical department under a non-engineering function. True, the controller exercises an independence of thought vital to satisfactory functioning of the time study department; however, the scope of the department's activities would be unduly influenced and limited by the cost consciousness of the controller. Accounting, oftentimes under the controller, is ordinarily concerned only with costs and not with particular methods or particular people. To be fully effective, the department's activities must be a part of a self-contained industrial engineering department reporting to the Vice President in Charge of Manufacturing Operations. This larger department should include the functions of: manufacturing

1. Carroll, Phil, Jr. 1938. TIME STUDY FOR COST CONTROL. p. 35, McGraw Hill Book Co., New York.

methods, materials handling, plant layout, special studies, and perhaps job evaluation. By so doing, true independence of thought and action is given to the overall function of industrial engineering, also originality and innovation are stressed as is operating economy. On the other hand, under the controller, the immediate costs savings would often be taken at the expense of permissible future operating economies through additional investment in time and money in new methods and equipment.

This self-same reason justifies the staff function position of the industrial engineering department clearly differentiated from that of the line. Independence of thought should be uppermost in the minds of an organization which must give constant attention to research and development. By the virtue of its objectives, motion and time study is associated with production research and development though obviously its activities are closer to applied research than to basic research. The theme of such a department should be "the best is yet to come." A constant search for new and better production methods is its daily task. This is accomplished simply by never recognizing a prevalent or a proposed method as the "best" method. A questioning attitude is the mark of a good time study engineer.

Industrial Relations:

Relationships between the time study engineer and the labor force and or the union has been the subject of much controversy. In many companies this has amounted to an almost complete separation of industrial relations activities from the time study engineer who reports his findings to others who do the negotiating on the basis of the data he has supplied. This is a waste of time and talent. The professional time study engineer must participate in the industrial relations phase of his work. He should be the one to explain his standards and his methods to the workers and the union representatives. He should be consulted by the industrial relations department during negotiations with the union in regards to grievances.

The "Time Standard:"

The result of the time study engineer's efforts is the time standard. The standard not only shows the quantity of work an employee must produce per hour and therefore the labor cost per piece, but it is the primary source of certain basic information needed by both operating and top management. It is the basis for modern mass production methods. An example of a completed time standard with its accompanying write-up is shown as Figures No's. 16 and 17. These two figures represent the front and back of the time study form.

Figure 17

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Achievements Of Motion And Time Study:

Management as heretofore mentioned, must contribute its share to the modern production process. It can not rely on wage incentives to encourage the production workers to take on management's functions and duties. Modern mass production methods have forced management to rely on motion and time study as a basis for many of the control techniques which enable management to contribute its share to the production process. Furthermore, motion and time study is not only one of the most effective tools for supplying management with pertinent information, but it is often the only method by which certain objectives may be accomplished economically. Economy is achieved by persuading the worker to participate more fully in the production process and by requiring and aiding management to be more effective in its functions. To visualize the situation certain musts for effective management should be itemized:

1. Methods and processes must constantly be improved in our dynamic society.
2. Methods and procedures must be standardized for any repetitive operation, but especially for high volume categories, to obtain lowest costs and the highest most consistent quality.
3. The workers must be satisfied and content.
4. Mass production means planning and scheduling for co-ordination, proper inventories, steady production, and maximum production in a minimum time.
5. Adequate controls must be secured for the labor force to:
 - a. Maintain a high productivity level through incentives.
 - b. Determine labor requirements.

- c. Determine what to expect from the labor force and consequently from the investment in plant, equipment, and inventory.
- 6. Operating costs must be pin-pointed. Standard costs must be determined.
- 7. Estimates for new models and for bids on contracts should be based on standard data not on guesswork. Pricing, in other words, should be an intelligent business function based on available facts.
- 8. Tools, jigs, fixtures, plant layout, and machines should be planned for maximum productivity and most economical cost considering certain financial and production limits.
- 9. A constant flow of new ideas and suggestions should issue both from the working force and from management to provide a foundation for progress.

Motion and time study is a basis for attaining many of these musts. It facilitates management's control over the methods and processes of manufacture. Carroll (1938)¹ states that the word control as applied to the uses of time study measurement means "to exercise a directing influence over the operations of a business." That means creating the circumstances, not merely accepting them as they are. He reiterates that the management that controls a business does not stand by and wait for things to happen, but takes constructive action in directing their course. Motion and time study is that tool permitting them to do this.

Improvements in methods and processes are necessary to maintain the industrial pace our progressing society demands. This means not only new methods for the manufacturing or

1. Carroll, Phil, Jr. 1938. TIME STUDY FOR COST CONTROL. p. 239, McGraw Hill Book Co., New York.

direct labor force but also for the indirect labor and maintenance forces which are a large factor in cost of goods sold. Time and motion study through its very nature provides for new methods and new processes. It guarantees that these essentials are not forgotten during the press of meeting manufacturing commitments. While it does not participate directly in basic research as to products, it does or should do so in regards to methods. However, its primary function is to develop and apply the latest and best methods and processes. Development work on such ideas and methods is the primary goal of motion and time study outside of establishing operating standards.

When a job is time studied, it is analyzed as to its place in the overall production process and also as to the required methods. Thus, new methods and motions can be developed consistent with the best in overall productivity and economy, also keeping the workers and the manufacturing plants' capabilities in mind. In many cases, of course, methods are also developed for the moment only. As production volume fluctuates, and the price or the investment varies so will the methods. Generally low production items demand that management temper its methods and equipment to match the limited revenues. This is the difference between the job lot shop and mass production factories. In the former, production is such

that special purpose machines are practically nil and as a consequence methods and layout are temporary in nature. The job shop is arranged for short runs with multi-purpose equipment. The mass production shop utilizes the opposite approach with its special purpose equipment, elaborate production lines, and expensive processes. High production generally permits the ultimate in manufacturing methods, processes, and layout.

Motion and Time Study in Indirect Labor Areas:

The indirect labor should not be neglected in regards to methods. Such work may be analyzed in many cases more easily than production operations. Standards may be set, though not in exactly the same manner as for production work. Generally the indirect worker can be required to meet the standard on a certain percentage of the jobs he undertakes. In other words, his results on one or on even several short jobs should not be taken as normal. It is obvious that in work such as that done by plant electricians and carpenters "unknowns" creep into the assignment which cannot be adequately foreseen ahead of time. This means that in a large percentage of cases, the worker will not meet standard but conversely he will better his standard on equally large percentages of the jobs he undertakes. Naturally his performance on the job can be measured after completion of the job when all of the details have been reported. This measure is not desirable in most

instances, and should not be applied to the individual without expecting ill feelings on his part, as he probably cannot judge his pace accurately enough to finish the job in a proper time. Performance of a group of employees, however, can be measured in this manner with no hard feelings and usually without their having to know it. Results of this kind can be used on a group basis.

This brings us to the real benefits that may be arrived by applying motion and time study to the indirect labor force. The individual worker's productivity is primarily of interest to his supervisor. Promotions, assignments, and even demotions can be weighed carefully in terms of work output along with skill and the other common factors of performance. Often the supervisor, himself, is called on the "carpet" so to speak. With production results on file, he knows where to concentrate his attention. He may supervise to some extent through use of the principle of exceptions. Concentration on the poorest areas may be easily directed through performance records.

Collective productivity is of interest to "top management". The data obtained on group results can be used by management in its determination of the efficiency it might expect from this segment of the working force. Again, this information can be used in budgeting, estimating, and bidding

with a resulting overall position which would be more beneficial to the work and management. Why, because management would know better what it is doing, what it is going to do, and how this may best be done. These things are foreseen and forecast by examination of past performance as contrasted to standards accurately set and properly used. Before the introduction of time study for the indirect labor, management was ineffective and faltering in its efforts to control this portion of the cost of goods sold. Perhaps the worst fault was in scheduling the work for crews of indirect workers. Time and money was wasted with the daily work assignments merely by the workers waiting to be assigned their work. With time standards, a foreman can calculate the completion of work assignments and schedule his work load as effectively as it is done in the production departments. Preparations may be made in advance for specific jobs by having material and tools ready for the crews. Machine shutdowns may be timed to coincide with available time on the part of the maintenance crews. A consequent savings in downtime may be valuable to the production worker who might be out of a job temporarily during the shutdown. Size of work assignments may be effectively estimated. In the case of janitors, areas may be assigned within the capability of the individual. Since the amount of work the individual should be doing is fairly

determined, previously unfair methods can be thrown out and a system of work assignments based on a normal worker may be set up. Further savings can result from improved work scheduling through proper balancing of the work load, and proper crew size determinations.

By adopting time standards for the indirect labor, the engineer was first forced to standardize methods and procedures for these workers. In itself this was a tremendous improvement. Gilbreth (1917) in his bricklaying experiments proved the effectiveness of establishing and standardizing on the best methods available. Each job assignment can be accompanied with a sheet of job instructions setting forth the procedures to be followed. Standard operating details are thus necessarily required. Indirect labor time study is effective primarily because the procedures it requires in themselves improve the efficiency of the working force. These procedures or methods could be used without time study, but in practice this is rarely done and would not be nearly as effective as the combination of the two. As in the case of production workers, efficient management and efficient workers mean low cost production with higher wages and greater sales.

Motion And Time Study And Morale:

A satisfied and contented working force is the essence of a successful manufacturing concern. Without cooperation of

the working force all plans will be more susceptible of failure or at the very least the accompanying dissention and ill feeling are liable to be the cause of slowdowns and strikes. A man may be content on his job only when his basic needs and desires are satisfied.

The Hawthorne₁ experiments proved that morale was the most important factor in obtaining maximum sustained output. The worker's emotional reactions--his feelings toward his fellow workers, his supervisors, his work and the company as a whole are the largest factors contributing to high productivity. Good morale cannot be obtained by discrimination, by time standards out of data, and thus unfair, or by an incentive system poorly administered. Management does not take the easiest way out by establishing an incentive system based on time standards. Vigilance, fairness, understanding, and honest hard work on management's part are necessary ingredients of such a system. Standards must not be permitted to get out of date, as a note of unfairness soon creeps in with its resultant effect on morale. A well administered time standards department and incentive program require active participation and understanding on the part of the company's executives. Standards can not be set up and then left alone with the hope that continuing rewards to the worker and to the

1. Roethlisberger, F.J. and Dickson, W.J. 1940. *MANAGEMENT AND THE WORKER*. 615 pp, Harvard Univ. Press, Mass.

company will be obtained automatically thereafter.

Alford (1951)₁ summarizes the results of Elmo Roper's polls of workers desires as follows:

1. Security through steady employment at good wages.
2. A chance to advance.
3. To be treated as a human being and not a mere number on the payroll.
4. A sense of dignity based upon the feeling that the work performed is useful to society.

Security may not be achieved through low productivity, as a depressions would soon substantiate. The efficient plants are those which have a management aware of operating conditions and costs and are ready to meet emergencies. Time standards provide the necessary information for management as to many operating conditions. Much of the guess work is eliminated from the vital business decisions. This establishes the employee's security better than any other factor.

A progressive organization in a dynamic economy always means expansion and promotion. More efficient labor and machinery means more profits, more wages, and greater sales. What else offers a better foundation for advancement?

Financial incentives treat the worker as an individual. No longer is he paid the average wage. The employee is an individual retaining the rights of an individual, the equitable

1. Alford, L.P. and Beatty, H. Russel. 1951. PRINCIPLES OF INDUSTRIAL MANAGEMENT.
p. 637, Ronald Press Co., New York.

results of his production; workers are paid according to their contribution.

A sense of dignity cannot be maintained or based on inferior workmanship. Management allows inferior workmanship when it fails to utilize the most effective and informative tools at its disposal. Time and motion study enables management to base its decisions on facts and to maintain proper control over all units of production.

Although mass production means an obvious recourse to scheduling, co-ordinating and using the other proven techniques of industrial engineering, these can also apply to job lot production. Only through monopoly may an industry continue to use outdated techniques. Even then it is a waste of talent, investment, and time. Job lot production demands efficiency in the use of the tools of production on the work at hand. Motion and time study can be applied to this type of business as it is applied to the indirect labor force which can be said to be engaged in a type of job-lot production. The likely success of such an application has been proven in the adoption of this technique by the thousands of garages throughout the country. When they refer to the handbooks published by the various automobile manufacturers that give estimates for different types of service work, they are using time study in their activities. Such time standards could be

effectively used by the thousands of small businesses throughout the country in effectively bidding on jobs, planning their work, and running an efficient business. Rarely would it be necessary in a small business to use standards in controlling the productivity of the working force. The manager is usually in such close contact with his men that this is unnecessary.

Motion And Time Study As A Foundation For Production Planning And Control:

Production planning and control entails planning, routing, scheduling, dispatching, and follow-up in the productive process. These functions must be so organized that the three m's of production--materials, and machinery, and men are effectively co-ordinated insofar as quantity, quality, time and place. Furthermore, this coordination must be done cheaply.

Scheduling is associated with the factors of production and primarily deals with time, quantity and place. Time for the production units can be effectively provided only by time standards. True, less complex scheduling may "get by" with less, but the crucial test comes in an industry like automobile manufacturing. Thousands of parts, large and small, moving through production and assembly lines could never be controlled without standard times. "Cooperation" could be possible but "coordination" never, without this basic management tool. Follow-up, or expediting, may easily be done through performance records similar to the one shown as

Figures No. 18 and 19. This and similar records give departmental performance as measured against a standard. Similar records may be made on a plant-wide basis. This again permits the use of the Principle of Exception for management's portion of the follow-up phase of production.

Control of the factors of production is the function of management. Individual control over workers is made effective through time standards in conjunction with such control devices as quality control. High productivity and high waste levels cannot go hand in hand for long. That is why time standards are only one of the many tools of management for employee control. Control is necessary in order to obtain high productivity from the employees. High employee productivity generally means high machine productivity if there is a capable management. Frequently the machine is all important because of investment; so little on the part of the worker often means so much on the part of the machine and consequently to production.

Motion And Time Study And Cost Control:

Proper determination and allocation of operating costs is a necessary part of efficient management control practices. Intelligent decisions concerning operating alternatives can only be based on complete accurate information as to the sources of various operating costs and their magnitude, together

WK NO.	WEEK ENDING	NO. OF EMPL.	TOTAL HOURS	DIRECT LABOR HOURS							
				HOURS ON STANDARD	DAY WORK HRS.	WAIT TIME HOURS	HOURS TO STD.	EARNED HOURS	E.H. OVER STD.	% PERF.	% ON STD.
1	2	3	4	5	6	7	8	9	10	11	12
1	7-6-52	88	2806.1	1198.8	110.7	157.7	63.9	1125.9	40.2	94.6	91.5
2	VACATION	-	-	-	-	-	-	-	-	-	-
3	VACATION	-	-	-	-	-	-	-	-	-	-
4	7-27-52	81	3202.8	1329.1	139.4	253.2	96.2	1232.9	27.3	92.8	90.5
5	8-3-52	99	3845.4	1608.8	101.0	191.0	112.7	1496.1	15.6	93.0	94.1
6	8-10-52	98	3888.3	1522.3	96.3	228.9	106.0	1416.3	32.3	93.0	94.1
7	8-17-52	101	4756.6	1785.9	86.0	270.8	166.6	1819.3	32.1	91.6	95.8
8	8-24-52	97	4469.6	1768.1	84.4	236.8	120.6	1647.5	20.5	93.2	95.4
9	8-31-52	94	3657.9	1400.0	90.9	159.6	79.7	1320.3	30.3	94.3	93.9
10	9-7-52	98	3871.6	1487.5	81.2	175.1	84.6	1402.9	32.9	94.3	94.8
INDIRECT:		OL/FR.	SET-UPS	INDIRECT							
13	14	15	14	15	16	17	18	19	20	21	22
1		1.1	112		1347.9						
2		-	-								
3		-	-								
4		1.2	123		1482.1						
5		1.0	154		1844.6						
6		0.9	167		2040.8						
7		1.0	147		2413.9						
8		0.9	156		2380.3						
9		2.2	133	2.2	2005.2		-0.1	2.3		104.5	0.1
10		0.8	105		2127.8						

Figure 18
Labor Analysis Report

WK. NO.	WEEK ENDING	AVG. HRS. PER. EMPL.	TOTAL LABOR HOURS								S.C.N.	
			HRS. ON STD.	DAY WORK HOURS	WAIT TIME HOURS	HOURS TO STD.	EARNED HOURS	E.H. OVER STD.	% PERF.	% ON STD.		SUPV. CLK. HRS.
23	29	28	26	27	28	29	30	31	32	33	34	
1	7-6-52	31.9	1189.8	1450.6	157.7	63.7	1125.9	40.2	94.6	55.9	377.3	
2	-	-	-	-	-	-	-	-	-	-	-	
3	-	-	-	-	-	-	-	-	-	-	-	
4	7-27-52	39.5	1329.1	1621.5	252.2	96.2	1232.9	22.3	92.8	55.1	362.0	
5	8-3-52	38.8	1608.8	2045.6	191.0	112.7	1496.1	15.6	93.0	52.6	403.6	
6	8-10-52	39.7	1522.3	2137.1	228.9	106.0	1416.3	32.3	93.0	50.4	438.0	
7	8-17-52	47.1	1985.9	2499.9	270.8	166.6	1819.3	33.1	91.6	54.0	571.2	
8	8-24-52	46.1	1768.1	2464.7	236.8	120.6	1647.5	20.5	93.2	50.9	525.6	
9	8-31-52	38.9	1402.2	2096.1	159.6	79.6	1322.6	30.3	94.3	48.8	442.4	
10	9-7-52	39.5	1487.5	2209.0	175.1	84.6	1402.9	32.9	94.3	50.3	538.4	
SPECIFIC CONTROL HOURS												
WK. NO.	LUNCH & WASH-UP HRS.	EMPL. ACT. HRS.	SET-UP HRS.	SALVAGE HRS.	DEV. HRS.	TRIAL RUN HRS.	PREMIUM ANALYSIS			ANAL. - EXEL. PREM.		
							O.T. PREMIUM HRS.	NIGHT SHIFT PREM. HRS.	PREM. COST/STD. H	WASTE %	WASTE HRS.	PREM. HOURS/STD. H
35	36	37	38	39	40	41	42	43	44	45	46	47
1	138.2	4.7	207.1	-	32.5	-	-	178.2	.10	503.1	22.0	1.28
2	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-	-
4	159.0	16.2	226.0	3.8	21.1	16.0	-	201.1	.10	673.8	25.3	1.34
5	191.7	-	251.4	-	36.7	25.1	-	237.8	.09	738.8	22.7	1.29
6	193.7	9.6	322.4	-	29.2	15.5	-	244.3	.10	783.7	24.1	1.32
7	222.7	8.5	277.2	-	45.7	1.7	372.9	304.8	.23	945.2	23.9	1.31
8	222.7	12.0	273.9	-	63.7	6.7	352.0	277.6	.22	868.7	23.4	1.31
9	181.8	3.0	253.8	10.7	33.2	4.0	-	233.0	.10	679.8	22.4	1.29
10	193.6	5.0	220.2	-	36.4	2.1	377.9	253.2	.26	701.3	22.4	1.29

Figure 19
Labor Analysis Report (cont.)

they indicate where the greatest opportunity lies for improvement. Management to be effective must concentrate its attention at trouble spots, bottlenecks, and the like. Serious limitations are often imposed on management because of financial conditions. Such limitations usually cause management to adopt the policy of --"To that which deserves the most." In effect, this means that the most profitable projects are the only ones undertaken. Even in the occasional instance when investment capital is plentiful, consideration must be given to the alternatives of investing the money outside the company as compared with investment in plant improvements or expansion. Most manufacturers base investment alternatives on the relative rate of return to be enjoyed by such investments. Estimates of returns are based on existence of accurately established operating costs. Motion and time study first breaks down the overall cost into cost centers which provide a basis for accurate cost assignments. Standard costs based on time standards enable management to assemble quickly and accurately the necessary cost information on proposed alternatives. Timely information is necessary to enable management to take immediate advantage of available opportunities.

Production is not the result of over pricing, below-cost estimates, and unrealistic bidding on contracts. A steady

customer may easily be lost as a consequence of a cost-plus contract which did not live up to the company's estimate of costs as given previous to the contract. Sales are made with realistic statistics on production facilities, capacities, and costs which are placed in the hands of the salesman. Most companies now realize that the salesman or the sales engineer must have a first hand knowledge of these things before he can obtain orders in many lines of business. In certain industries a salesman must frequently be able to quote almost immediately the price for speciality production items, perhaps in many cases never made to exactly these specifications before. Standard sales data may be prepared for these men which will give information on which to base their pricing. This sales data should be based on operating standards and operating costs which in turn are based on cost and time standards. Not many manufacturers as yet provide their salesmen with this information, but the trend is in this direction. If the salesmen are to be "limited agents" of the company, they must be provided with such information as will enable them to act intelligently.

Home office pricing is not exempt from the need for pricing and estimating information. In many cases this is done on the basis of historical costs on previous production runs. This information does not answer the full need of estimating

personnel. Government contracts and contracts let by major companies to smaller organizations or to specialty organizations call for a superior type of estimating. This can best be secured through the minute breakdown given by time standards. Standard data obtained through time study is extremely helpful in these cases for development of predetermined costs.

Motion And Time Study And Human Engineering:

Demand for maximum productivity from the investment means that all machinery, tools, buildings, and equipment must be designed for maximum utility and convenience to the operator. Human engineering can be described as the design of these elements of production with the individual in mind. Industrial engineering encompasses this wider engineering horizon by taking into account all factors of production including the individual. Time study is the phase of industrial engineering most concerned with human engineering. Efficiency for the operator can be designed into the factors of production only through motion and time study. It has already ruled out in the majority of mass production industries the use of such archaic devices as the hand truck for moving products into and out of storage areas. The mechanized fork truck or pallet mover is mostly in use now, and frequently conveyors have replaced the trucks. Why has this been done? Time and dollar savings are the answers. In many cases improvements in time

as indicated by time standards were the deciding factors. For example, quick-acting clamps for jigs and fixtures were readily proved to be much more effective and economical than the nuts formerly used to secure parts into place in these devices.

Ideas are the essence of progress. New suggestions of production ideas should be forthcoming from the time study engineer with every study he makes. The detailed analysis of each job as demanded by time study procedures almost predetermines improvements in methods and procedures after a job is studied. The success of time study engineers in the business world has in many cases been due to the training in precise observation that they received when taking time studies.

Standard Time Data:

Time standards can be determined by several alternate methods. One method is gaining increasing favor in the last few years. It is known as the "standard data method." This technique is based on the principle that there are certain fundamental motions which compose a person's movements when performing any physical task. Standard times are assigned to these basic movements of the human body. These basic movements are "therbligs" or combinations of "therbligs." (For a definition of therbligs, see the appendix.)

Standard data may also exist for the elements into which an ordinary time study can be broken down. This standard data is combined into the more common elements used in more than one operation or on similar jobs. Basic standards may also be established in a variety of ways from predetermined machine or processing time, by accumulated data from actual time studies, by motion analysis, or by a combination of the above methods. There is one restriction, they must always represent the time for "normal" performance of the work done.

Advantages of predetermined time standards are multifold. Its particular advantages over watch studies are as follows:

1. Greater consistency can be maintained than with individual time studies.
2. Time standards may be established when or before they are needed without having to wait for the job to be run. Establishing standards at the convenience of the time study engineer and not the production department is particularly important in scheduling the departmental work load.
3. Special runs are not required to determine standards.
4. The controversial features of effective performance rating are removed.
5. Estimating may be done with greater accuracy, speed, and economy.
6. Through proper explanations, greater acceptance can be obtained from unions and workers.
7. Impersonality of such standards promotes acceptability of them.
8. Time standards can be reproduced if necessary and also be checked easily. Consistency in standards established by all members of the department is readily maintained.
9. The cost of the standards is considerably lower than those resulting from timing with watch studies.

Synthetic time standards rest on the foundation that the correct standard for any operation is the sum of the time allow-

ances for individual elements composing the operation.

Taylor (1911)₁ in "Scientific Management" observed the following in support of the standard data method of time study:

"No system of time study can be looked upon as a success unless it enables the time observer, after a reasonable amount of study, to predict with accuracy how long it should take a good man to do almost any job in the particular trade, or branch of a trade, to which the time student has been devoting himself.

It is true that hardly any two jobs in a given trade are exactly the same, and if a time study student were to follow the old method of studying and recording the whole time to do the various jobs which came under his observation, without dividing them into their elements, he would make comparatively small progress in a lifetime, and at best would become a skillful guesser. It is however, equally true that all of the work done in a given trade can be divided in to a comparatively small number of elements or units, and with proper implements and methods it is comparatively easy for a skilled observer to determine the time required by a good man to do any one of these elementary units."

The economic disadvantage of this fundamental method is primarily confined to the small company which cannot invest the money to develop a system of time standards. Current work in compiling a standard data system of universal availability, however, is being done by the Society for the Advancement of Management. It should be available within a few years to the industry at large.

The standard data method based on previously timed elements of some specific job is usually applicable only to

1. Taylor, F.W. 1911. SCIENTIFIC MANAGEMENT.
638 pp. Harper and Sons, New York.

similar jobs, in similar industries, which contain these self-same elements. Of more universal applicability is the system of breaking down the elements of a job into their component parts and assigning times to these parts, thus making them available for any job. The work being done by the Minneapolis-Honeywell Regulator Co. on such a system is remarkably progressive. Honeywell's time study department has evolved standard times for the various fundamental motions. From this standard data, they have developed elemental time standards for the various machines and the different types of work being done in their shops. An example of such data is included in Figures 20 and 21.

Alford and Bangs (1949)¹ in commenting on the relative costs of the standard data system versus the watch study method report as follows:

"Thus cost per standard by the standard data or indirect method is only about one third of the cost by the direct method. Frequently coverage of work by standards is 40% under the direct method (watch studies), as compared with 95% under the standard data method."

This is primarily due to the difference in speed between the two methods and the savings in labor on the part of the time study engineer. Envisioned for the future is the possible combination of time standard data and the "electronic computer" so that the information could be fed into the machine

1. Alford, L.P. and Bangs, J.R. 1949. PRODUCTION HANDBOOK. p. 525, Ronald Press Co., New York.

and the job time standard would be forthcoming in a manner of seconds.

Seasoned time study engineer's have all experienced the frustration of having to wait before an important operation is run in the shop so that it can be timed. Synthetic time standards will soon enable them to "time" at will, as long as sufficient information on the job characteristics has been recorded. If correct standard practice methods have been followed, and adequate operation instruction sheets have been written, job characteristics will be on record automatically. The cost of special runs for time study purposes will thus be avoided. Scheduling can be set up before the first run of a new product. In an assembly industry, such as automobile manufacturing, this is important to both the worker and management because delay is minimized when new models are being produced for the first time.

Effective performance rating and the accuracy of the individual time study engineer have always been a source of grievances on the part of the worker and the union. Standard data eliminates this situation and also provides the consistency lacking in the watch study method. For wage rate purposes, consistency is even more important than accuracy. This may sound strange, but the union can bargain collectively against an inconsistent set of time standards on the basis

T.S.E.	DATE	FOREMAN	DRILL PRESS OBSERV. SHEET						MATERIAL		PART NO.		OP. NO.					
M.W.B.	3-27-58	E.E.L.	P.T.S. 121 (4-2-52)						STEEL - SPEC. #19		FB-28783		X-4					
ELEMENT DESCRIPTION			BASE TIME	ADD'L TOOL TVL. OIST. TIME	TOT. COMB. TIME	FREQ.	TOT. TIME	ADD'L FACT.	ADD'L TIME	JIG CLASS - I JIG WEIGHT - JIG NO. - ANGLE REST DESC. - DIMENSIONS -								
AIR CLEAN JIG			.0258				.0258			MACHINE CALCULATIONS								
GET PART FROM PAN OF STANISOL ON MCH. TABLE			.0203				.0203			MACHINABILITY								
LOAD - OTR			.0153				.0153			EL. APP. NO.	DR. LEN. PT.	LEN. OF CUT	TOT. TOOL TH.	FEED	RPM	DIAM.	CUT TIME	
CLAMP W/ CAM LEVER			.0225				.0225			6	.031	.0216	.1250	.1820	.0020	2300	.0760	.0396
POSITION @ SPP'S NO. 1			.0227				.0227	.0056										
DRILL 4) #49 DIA. HOLES			.0396				.0396											
LEVER UP & RELEASE			.0058				.0058	.0056		TOOL CARE								
UNCLAMP			.0189				.0189			TIME	TOOL NO.							
UNLOAD			.0051				.0051			.0033								
DISPOSE TO TRANS. PAN. ON MACH. TABLE			.0066				.0066			GAGING								
										EL. TIME	GAGE USED							
										.0182	IA2 GET GAGE							
										.0065	IA10 DISP. L.G.							
										.0370	II B1 WASH PART							
										.3581	VE1A USE PLUG							
										.0222	IA9 GET GAGE							
										.0065	IA10 DISP GAGE							
										.0616	USE (DTPR + DN) X2							
									.0069	.5201 ÷ 75								
										MISCELLANEOUS								
										SET (500) CONV. IN PAN OF								
									.0010	STANISOL ON MACH. TABLE								
										.0340 + 8 (.0402)								
										350								
										SET CONV.								
									.0002	CONTAINER HDLG. 5 5800								
									.0007	R 1000								
									.0123	TOTAL CHORE TIME								
									.1948	TOTAL ELEM. TIME								
TOTALS							.1836	.0112	.2070	TOTAL CYCLE TIME								

Figure 20
Time Study Observation Sheet

PART NAME- PLATE		INFORMATION SHEET		DEPT - DP-160		PART NO - F828783	
MATERIAL - STEEL		D.M.E. - F.A.S.		T.S. SUPER. L.N.		OPER. NO. X-4	
SKETCHES, ETC.		OPERATION DETAIL -		SPEED FEED		EQUIPMENT	
		DRILL (4) HOLES				D-30	
		USE STEADY FLOW OF OIL.				U.S. DRILL HD.	
		USE (1) STATIONARY TUBE WITH CONSTANT FLOW OF AIR TO CLEAR CHIPS				DPD-559-G	
		SET PARTS CONVENIENT, IN PAN OF STANISOL ON MACH. TABLE.					
		GET (1) PART, LOAD, CLAMP.					
		DRILL (4) #50 DIA. HOLES THRU		2300 H.		(4) #50 DRILLS	
		UNCLAMP, UNSLOAD PART, TOSS DISPOSE TO PAN ON MACH. TABLE.					
		GAGE (1) PART EA. (350) PCS.				GAGES:	
						OG-1844	
						OG-1845	
						OG-1559	
FATIGUE ALLOW. CODE MIN							
MENTAL & VISUAL		3 12					
WKG. CONDITIONS		3 8					
POSITION OF OPER.		1 0					
WEIGHT & CYCLE		46 15					
TOTAL FATIGUE		35					
WAITING / 8 HRS.		-					
FATIGUE ALLOW.		35					
PERSONAL ALLOW.		15					
MINOR DELAY ALLOW.		15					
TOTAL ALLOW. / 8 HRS.		65					
MIN. CYCLE TIME	EFF. MIN / HR.	HR. / M.	PCS. / HR.				
2070	51.9	4.00	250				

Figure 21
Time Study Observation Sheet (back)

of injustice it causes in pay to the workers. The errors in watch studies can be weeded out from standard data. Standards may easily be brought up to date and minor changes in methods may be easily accounted for at a minimum of expense. The result is a set of "up-to-date" standards available without delay in day-to-day work. As Carroll (1938)₁ states:

"By the standard data method, inconsistencies occur only when the process of manufacturing is outlined differently, and when certain elements are added or left out in error. When these errors are investigated, it can be demonstrated that by their elimination the two standards become strictly comparable."

Explanation to the workers is important. With a system of time study based on standard data, the whole system may be examined and explained once and for all. Job standards set subsequently are generally not subject to debate. Watch studies, on the other hand, must be individually explained to and accepted by the workers. These repeated explanations are an outright loss of time and money and often result in ill feeling on each side.

Reproduction of time standards is frequently required. Generally this may be done conveniently if not with ease from standard data, by an experienced engineer. Conditions are necessarily detailed to the minutest motion. This is not always true with watch studies. When taking a watch study,

1. Carroll, Phil, Jr. 1938. TIME STUDY FOR COST CONTROL. p. 65, McGraw Hill Book Co., New York.

the time study engineer may neglect to reduce to writing certain conditions which he believes are standard or unimportant. Changing conditions alter the job, and when the standard is challenged, it cannot be reproduced. As a consequence, the time study engineer's reputation and the company's honesty in backing up the otherwise sound policy of guaranteed standards are both questioned forcibly. Morale of the workers and management are both affected in such circumstances.

A Typical Application:

In the Process Guide issued to industrial engineers for use in estimating work, the Minneapolis-Honeywell Regulator Co. (1952)₁ advises their engineers as follows:

"The ability to forecast future costs with a fair degree of accuracy is the keystone of intelligent planning. Knowledge of the efficiency of labor, the evaluation of various methods of manufacture, analysis of machine capacity, production costs, investment in new equipment, etc. are fundamental to a stable economy.

Estimates are individual opinions. How closely these opinions reflect true shop operating conditions indicates the quality of the estimator. To attempt to estimate the time the shop will provably take to do a job is an exercise in futility. The procedure to follow is to estimate for a normally efficient shop performance and then for the purpose of cost accounting, allow the cost department to apply a factor for shop efficiency.

The basis upon which reliable estimates are made is Standard Data."

1. Minneapolis Honeywell Regulator Co., 1952. PROCESS GUIDE.
p. 2, Minneapolis Honeywell Regulator Co, Minneapolis.

The manual then provides a series of estimating analysis sheets and outlines conditions under which they should be used. These sheets are based on standard data and enable the engineer to efficiently produce reliable estimates. Figure 22 is a reproduction of the analysis sheet used in a study of certain types of automatic screw machines. In estimating costs, the industrial engineer first determines all operations for each part of a product; then, on the basis of the analysis sheets and cost information he assembles the production cost for the part. Costs for individual parts are then assembled into the cost of a complete product, to be used for pricing, bidding, scheduling, and like assignments. This example shows the extent to which time standards may be utilized by a progressive management.

Limitations, Errors And Misconceptions Concerning Motion And Time Study:

Economic limitations are not those usually contested by the union. These usually involve only the degree to which motion and time study techniques may be utilized. Many times where the operation is highly mechanized and the labor cost is small or even negligible, there is no necessity for time standards as achieved through time study. Labor savings would perhaps not even return the cost of the study. Also, many experimental or temporary jobs exist from time to time.

PROCESS GUIDE Estimating Analysis Sheet		
Machine Types: 5 Spdle. Davenport Automatic 1 3/4 & 3 1/4" 5 Spdle. W & S Automatic Screw Machines 2 & 2 5/8" 6 Spdle. Acme Gridley Automatic Screw Machines	Location ASM-140	Machine No A5D A5W A6G
Estimated Std = $\frac{(\text{Mach Time} \div \text{Manual Time}) \times 1000}{51.8 \times \text{No. of Machines/Operator}}$		Hr/M Est.
Number of Machines Per Operator = 2 Present Policy Machine Time: a/ Select the Longest Cutting Operation b/ Determine Revolutions for Longest Cut c/ Divide Revolutions by RPM Used d/ Add in Machine Idle Time Idle Time: Revolutions = $\frac{\text{Len of Cut} \div \text{Ap} \div \text{OT}}{\text{Feed}}$ A5D = .0067 A5W = .0393 A6G = .0500 Mach. Time = $\text{Rev/RPM} \div \text{Idle Time}$ Manual Time (Tool Care, Etc.): Use Follow. Mach Time (Brass, Alum., etc.) Use 10% of Mach Time (Free Maching Steel, etc.) Use 15% of Mach Time (Stainless Steel, etc.) Use 20% of Mach Time		Hr/M Act. OperNo &/or Desc. P.E. Date Dev No & Sta. Part Name Part No

Figure 22
Estimating Analysis Sheet

The economics must generally be determined by examination of the individual case. Of a similar nature, is an operation performed so infrequently that time standards are not justified.

The most frequent limitations to time study are imposed by the worker, consciously or subconsciously. He often dislikes to be timed or to work under standards. He does his best to thwart the time study engineer in most cases. Extra motions and unnecessary adjustments crop up after the mere appearance of a time study engineer in the shop. Illustrative of such feeling is the ditty reproduced below from the union newspaper at Minneapolis-Honeywell.¹

"The Time Study Song-(to be sung to the tune of 'cold, cold heart')

I work like Hell
For Honeywell
I know I earn my pay;
And they send a jerk
Who never worked,
To check my time each day;
I've lost my guts,
I'm going nuts,
Now I'm St. Peter bound;
- I hope the bloke
Some day will choke,
That brought time study on."

Although meant to be humorous, this indicates some of the feelings and concepts prevalent in the workers minds towards time study.

The company compounds this problem when management does

1. Local 1145, CIO Paper. 1952. Minneapolis, Minn.

not keep a large majority of work in departments on standard. If time standards are set consistently and as soon as possible at the start of a new "run", resentment at being timed is negligible. It is taken as a matter of course that the operation will be timed. Workmen, however, are no different from anyone else in looking for advantages to themselves. If setting of time standards is delayed, later resistance is encountered to change, and the worker actually pits his brains against that of the engineers'. McNaughton (1945)₁ emphasizes this point when he states: "In normal times a worker seems to object to the use of most effective methods most frequently on the score that he may 'work himself' out of a job.' Unfortunately there is a very real basis for this obstacle." Many companies effectuate improvements as a result of motion and time study. Thereafter, as soon as possible they lay off workers in the involved departments. This is a poor policy which negates a large portion of the gain from the changes. Ideal conditions should see the gradual installation of any major change with the workers involved assimilated into other departments. In cases of changes affecting only a few positions, there is little excuse for management to discharge the workers.

1. McNaughton, Wayne L. 1945. INDUSTRIAL ECONOMY AND LABOR CONTROL.
p. 23, Golden State Publishers, Los Angeles.

Errors are also introduced into a time standard through haste or negligence on the part of the engineer. Pressure should not be brought to bear on the individual engineer to the point that he is caused to hurry through his studies. Negligent engineers should be reassigned or discharged as there can be no excuse on the company's part for affecting the wages of numerous employees through unprofessional behavior of one engineer.

Companies, i.e. "top management" are often negligent too. Frequently at the onset of an economic recession "cost cutting" is done first at the expense of the time standards department. They feel that once all current rates are established, the engineering force may be cut to the bone. This eventually confronts the remaining engineers with the problem of insufficient time to correct old standards in terms of the latest changes in operating conditions. The manager of the job and time standards department, of an eastern firm, prominent in the field of incentives and time study states:¹

"I am firmly convinced that neither the piece work plan nor the Bedeaux plan failed at -- -- --, but rather that management repeatedly has failed at its task of adequately administering its incentive wage programs."

He continues this theme by emphasizing that out-of-date standards were the cause of the trouble. Such accusations are

1. Due to the personal nature of the comments received in this letter, the source is omitted.

serious charges against any management. This, if true, means that management is ignorant of its duties and even more is relying on defective methods and systems to do its work. Standards which are inconsistent are worse than no standards as they lead to further compounding of inaccuracies and injustices.

Motion and time study has been accepted by many responsible individuals because of the charts, statistics, graphs and procedures which purportedly represent the scientific method of establishing standards. These people have become confused between the terms system and science in some cases. Motion and time study practitioners often deviate from the scientific method by not reporting conclusions in terms of implied assumptions. Detailed scientific evidence of the reliability of various systems of setting time standards is commonly lacking. The prevalence of the "efficiency experts" in the early twenties emphasized this tendency. These so-called "experts" founded and installed time study and incentive wage plans which were based on anyone's assumption and in some cases fantasy. Even now, various standard data systems are being evolved which have omitted one of the primary stages in the scientific method, that of rigorous checking and verification. Recent assumptions made are that times established for certain elemental movements are universally applicable without statistics

to prove this to be the case.

The effects of many outside factors, such as the bulkiness of the object to be carried, the weight of a part, the effect of combining two elements not naturally performed in succession have not as yet been fully considered. Various permutations and combinations of elements have not been investigated thoroughly enough to determine the effect that they would have on the overall difficulty of the operations and on the time involved.

The assumption is still being made that there is an absolute elemental human motion which has a universal time standard. This is commonly accepted as a fact by many proponents of the standard data system of predetermined time standards. This implies that any pattern of human movement is composed of separate and distinct motions each with an absolute individual time value, and if any one of these motions is removed the total time is reduced by an equivalent amount. The assumption is that the whole is equal to the sum of its obvious parts. Jennings (1954)₁ experimented with the effect of "manipulation time" on the travel time of "reach." His results indicated that as friction increases, the travel

1. Jennings, E. E. 1954. THE VALIDITY OF BASIC ASSUMPTIONS IN MOTION AND TIME STUDY. p. 16, Journal of Industrial Engineer, Vol. 5, No. 2, March, 1954.

time for "reach" increases substantially. He quotes the experiments of several other engineers which also have come to the same conclusion that time required to perform a basic motion, among other basic motions in a total pattern of movement, will vary significantly with preceding and following motions. Also, the basic motion will be substantially affected by conditions either directly or indirectly associated with it. The results of Jennings experiments have therefore cast a serious doubt on the assumption of independent fundamental movements with absolute time values. Managements should invest in research to re-evaluate the current standard data systems. The effect of associated movements and conditions should be secured from basic research and upon experimentation and trial incorporated into the standard data systems.

Another current assumption of motion study that remains open to question is the principle that "motions should be confined to the lowest possible classifications in order to reduce fatigue." One has only to become an amateur telegrapher to become qualified to cast subjective doubt on this statement. Only a few minutes of "code" work would convince the amateur that arm movements reduce rather than increase fatigue when operating a telegraphers key. Admittedly the motions with the lowest classifications are the quickest, but fatigue, noise and other factors appear to have considerable effect on them

as in contrast to movements of higher classifications.

Rigorous application of the scientific method to motion and time study would imply that all axioms and basic assumptions must be investigated before establishing a program or method based on them. This has not been done as is evidenced by the dire lack of basic research on the subjects mentioned. Experiments have been few, but worst of all they have been limited. Results are inconclusive and insufficient to enable statistical determination of the reliability of the basic assumptions. A more cautious approach to the use of the data already produced is suggested, at least checking by the simplest of experiments. Jennings (1954) suggests that perhaps the whole principle of establishing time standards from elemental data should be abolished. The errors involved, however, are not large in the engineering sense and available research data cannot approve or disapprove this statement. Certain to be investigated soon is the possibility of reducing to common denominators the effects of motions and circumstances upon time standards.

An outstanding critic of many time study rating procedures is Adam Abruzzi (1954) now an Associate Professor at Stevens Institute of Technology. Abruzzi has often criticized current time study practices in the light of statistical quality control techniques. From his studies he concludes that rating

or leveling is the most controversial and weakest aspect of time study due to the subjective features of this evaluation procedure. He quotes Carroll (1938) and other writers to the effect that objective scientific methods would be best, but they mostly remain to be worked out. Abruzzi asks the question, why should the subjective methods be the correct way to rate an operator? This subjective approach by an engineer, he says, implies that it is as accurate as objective methods. Also, he questions the worth of pooling subjective judgments and then considering the average more accurate than the judgments individually. He raises important points that bear investigation.

The increasing awareness among time study engineers and other industrial engineers of the scientifically unsound features of motion and time study is of note. This means that in the not too far distant future the various research projects being conducted, among others by the Society for the Advancement of Management and several universities should provide us with scientifically arrived at revisions for time study procedures. Management should recognize that time study is one of its most valuable tools, and as such they can well afford to finance basic research into its assumptions and also promote applied developments in this field of industrial engineering.

Chapter VI

UNION ATTITUDES
TOWARD WAGE INCENTIVES AND INCENTIVE MANAGEMENT

Industrial unions have not established a single, cohesive attitude toward wage incentives or incentive management. In fact there is a wide-spread divergence in union attitudes toward them. The position of a particular union usually reflects past experiences in connection with such systems and also by the problems prevalent in their particular industry or field.

Typical of such views are those expressed by the UAW-CIO. Correspondence with Nat Weinburg (1953)₁, their Director of Engineering and Research brought the following statement:

"As you may know, our union has taken a position in opposition to the spread of incentive systems to plants where they do not now exist, seeks to control them vigorously to protect the workers' interests in plants where incentive plans are now in operation, and, as a matter of policy, reserves the right to get rid of them where they are abused."

From Mr. Weinberg's statement we may see that the UAW is generally opposed to wage incentives. The diversity of views toward wage incentives within the AFL is illustrated by the following quotation from Boris Shiskin (1953)₂, Director of Research, AF of L:

1. Weinberg, Nat. 1953. Letter to M. W. Burke dated January 21, 1953.
2. Shiskin, Boris. 1953. Letter to M. W. Burke dated February 26, 1953.

"You probably realize that policy regarding incentive wage problems is a matter which is generally decided by the individual local or international union."

Generally sympathetic treatment of wage incentives is given by the apparel trades' unions. These unions have long been characterized as "piece-rate" industries. In the construction trades, time rates have generally prevailed.

Why the opposition on the part of some of the unions to wage incentives? There are many points of opposition, the primary ones being:

1. Past experience with rate cutting and speed-up.
2. General distrust with impersonal nature of time study methods.
3. General fear of unemployment due to additional productivity per worker.
4. Dilution of skills caused by break-down of crafts into semi-skilled operations.
5. Competition among workers and variations in earnings, leading to break up in the cohesiveness of the union.
6. Fear of low level of base pay.
7. Problems in administration of wage incentive plans.
8. Lack of coverage for all employed.
9. Possible effect on workers' health through over-exertion due to effects of incentive payment.

Isolated instances bring to light additional grievances, however, these are the primary objections.

Rate-cutting and speed-up characterized many of the earlier wage incentive systems. This was in evidence particularly during and after World War I, when so-called efficiency experts were installing wage incentive programs either not based on a sound engineering study or operating under principles contrary to accepted industrial engineering practice of

today. J. K. Loudon (1944)₁ explains:

"This over-demand for the services of trained, qualified men laid open the profession of Industrial Engineering, as it is called today, to the untrained opportunist, to efficiency experts with little if any qualifications, and to others whose prime motive was 'to cash in' on this new profession. Industry and industrial engineering, will be a long time recovering from the evils wrought during the years 1915 to 1930 and they have already paid a heavy price."

Added to this situation is the fairly obvious fact that many managements' did not keep faith with the programs. As Barkin (1951)₂ described the past practices, "They introduced complicated and mysterious plans, and, in their drive for lower costs, did not respect employees' rights and equities. Rates were cut. The result was that many programs had to be abandoned." Of equal importance is the fact that most progressive managements, today realize the disastrous effects of mis-management of incentive systems. The appreciation of need for guaranteed time standards has become an almost universal criterion of a successful wage incentive system. This development, occurring over the past few years, has influenced considerably the views of various unions and their members. Soldan substantiates this viewpoint in his discussion of wage incentive plans and their usage.

1. Loudon, J. K. 1944. WAGE INCENTIVES. pp. 2,8, Wiley and Sons, New York.
2. Barkin, Solomon. 1951. MANAGEMENT'S ATTITUDE TOWARD WAGE INCENTIVE SYSTEMS. p. 94, Ind. and Lab. Rel. Rev., Vol. 5, No. 1, Oct., 1951.

The impersonal nature of time study, upon which most incentive systems are based, is an objection encountered in the operation of an incentive system. The coldly, scientific way many time study engineers set rates frustrates the workers. They say, often vociferously, that what they actually do makes no difference as the time study engineer will "weed out" what he doesn't want. This, of course, is true particularly of standard data systems, since the operator can do very little to affect a statistical standard, the more so if it is based on a true plant-wide average.

Fear of unemployment was especially prevalent throughout the depression. The relatively good times experienced by most workers during and since World War II has allayed these fears. The workers and their unions still maintain, however, that the additional productivity gained per worker under incentives means taking that work away from a supposedly potential worker. The fact that increased productivity in the long run means increased production for the benefit of all is rarely considered, if at all. This same objection could be leveled against almost any improvement if the situation as a whole is not viewed.

The "dilution of skills" objection is primarily an objection to the factory system and mechanization. Incentive systems have been singled out because of their more obvious

vulnerability to such complaints. This objection should not be explained in terms of incentives or time study but rather in terms of our present socio-economic structure. Some justification for this belief is found in the tendency for workers to remain at their old skills rather than advance to new ones because of the temporary individual wage cuts involved.

Competition among workers under incentives has had a deleterious effect on intra-union and inter-worker relationships. The setting of artificial goals, high or low, on the part of the majority of workers provides no security since they can be broken by individualists, thus creating hard feelings. In group incentives, the naturally slow or lazy worker is ostracized by the group. Grievances raised by the workers must be handled by the union. This leads to a feeling of animosity toward the union by the worker when he fails to win his case. The argument is raised that incentives make a worker's earnings dependent on his own initiative rather than the union's bargaining.

High earnings under piece work or incentives lead to the establishment of low base rates by the manufacturer in order to reduce his costs of less efficient labor. This has happened in the garment industries in the past, and the unions feel that with the advent of hard times or a high level of competition it would again become a threat. They definitely

do object to this potential club being held over their heads. Today unions are alert to this threat, and by watching corporate earnings, wage trends, and other factors they are quick to act aggressively against it.

The majority of the administrative problems which are the cause of objections by the unions are in reality evidence of poor management. Factors such as delays interrupting the flow of work and consequently the employee's earnings are the focal point of the union grievances. Failure to maintain plans that were originally well-designed is another serious objection. Management has in times past met competitive conditions by reducing the size of the incentive program staff and consequently let their standards get out-of-date. These objections only emphasize the need for management to realize its responsibilities in the operation of a successful incentive system.

Lack of coverage for all employees has been not so much a target of the union as a problem for management. Production workers cannot maintain constant production without adequate cooperation from inspectors and supplymen. With the development of "indirect" time standards, these workers can now be covered as easily as production workers.

Effect of incentives on the workers health should be of concern to management, the union, the employees and the

community. Curbs should be devised and placed on the worker susceptible to overworking himself. These have been established almost universally in terms of eight hour days, rest periods, medical examinations for job fitness, and sick leave.

Unions and organized workers express their ideas and feelings about incentives through at least one major outlet-- collective bargaining. Grievance procedures, passive and active resistance, and union procedures, also allow for release of expression concerning wage incentives. These at best point to sporadic adjustments in incentive programs. Through collective bargaining the employees may express their long range views concerning the incentive program and negotiate safeguards and curbs they feel necessary in the program's operation.

Collective bargaining agreements provide a wide variety of and in many instances contrasting provisions pertaining to incentive plans. A pamphlet issued by the U. S. Dept. of Labor (1948)¹ contains a series of illustrative clauses dealing with wage payment methods, most of which in its words are "concerned with establishing safeguards and controls against abuse of the incentive wage principle." The majority of

1. U. S. Department of Labor, Bureau of Labor Statistics. 1948. COLLECTIVE BARGAINING PROVISIONS, INCENTIVE WAGE PROVISIONS; TIME STUDIES AND STANDARDS OF PRODUCTION. p. 4, Government Printing Office, Washington.

the contract provisions do not attempt to describe in full the particular plan in use. Illustrative of the few that do is the following excerpt from the agreement between the Benjamin Electric Mfg. Co. and the United Electrical, Radio and Machine Workers of America (1945)₁. Even it contains very little detail.

"The new incentive system shall be a standard time system wherein a 1% pay bonus shall be paid for each 1% increase in production above the standard."

Other paragraphs relate to operating procedures to be followed in setting standards on which the incentives are based.

The UAW-CIO believes in one primary contractual safeguard against incorrectly used incentives. Mr. Weinberg (1953)₂ emphasizes this as follows:

"In my own opinion, which I believe is shared by many others in UAW-CIO, the most effective contractual safeguard against abuse of incentive systems is the right to strike in disputes arising out of them."

Safeguards for time study methods are as important as those concerning the incentive program itself. Provisions for union participation in rate setting are not uncommon. Management usually strives to limit such outright union participation as an infringement on management's responsibilities. Unions often become active in rate setting upon institution

1. Benjamin Electric Co. 1945. AGREEMENT BETWEEN THE CO. AND LOCAL 1150, UNITED ELEC., RADIO & MACHINE WKRS. OF AMERICA. p. 19, Benjamin Electric Co., Des Plaines.
2. Weinberg, Nat. 1953. Letter to M. W. Burke dated January 21, 1953.

of an incentive or time study system, but eventually many lose interest when disputes are few and the employer fair. Minneapolis Honeywell Regulator Co.¹ had such an experience with Local 1145, CIO. The union provided several men who were trained by a consulting firm in time study methods. These union time study department personnel checked rates that were aggrieved by a union member. So few cases of disagreement with the original rate were found that the union abolished its time study department.

Incentive management as a controlling mechanism of industrial management has not received too much criticism from the unions. As explained heretofore incentive management does not necessarily include financial incentives, but requires both the workers and management to contribute to any increased productivity. A good example of union thought concerning incentive management is presented by Barkin² with this statement:

"The extension of collective bargaining and the growing power of unions assure greater acceptance of deliberate procedures in making changes, more careful planning, protection for the affected employees, and wider showing of the benefits. These developments have tended to reduce suspicion toward industrial change and to increase its acceptance."

Change is one of the primary attributes of incentive management.

1. Author's experience as engineer at Minneapolis-Honeywell
2. Barkin, Solomon. HUMAN AND SOCIAL IMPACT OF TECHNICAL CHANGE.
p. 16, Textile Wkrs. Union of America, CIO, New York

As exemplified in improved working conditions, materials handling, and management procedures Barkin elaborates:

1
 "Good planning, precise scheduling, careful layouts, accurate coordination and well-designed job patterns and subdivisions will contribute to excellent production results--. These programs have been strengthened by advanced managements with the advent of Unionism."

So actually the union has generally accepted the methods of incentive management while perhaps not quite "swallowing the whole pill."

Incentive management can be a means of instituting even greater union-management cooperation. This has been achieved in such activities as safety, and in adjustments due to production changes. Incentive management should be just the forerunner of incentive unionism.

1. Barkin, Solomon. TRADE UNION ATTITUDES AND THEIR EFFECT UPON PRODUCTIVITY.
 p. 15, Textile Wkrs. Union of America, CIO, New York.

Chapter VII

CONCLUSIONS AND RECOMMENDATIONS
FOR ACHIEVING GREATER PRODUCTIVITY
THROUGH INCENTIVE MANAGEMENT

Attainment of efficiency in industrial management is made easier by "incentive management." Industrial leadership is provided with the working tools for obtaining greater productivity from its investment in modern industrial engineering methods. Motivation for application of these methods is provided through "incentive management." This means in effect that management undertakes active cooperation with the employees in order to obtain greater efficiency. To do this management must prepare for change and promote ability and progress on the part of the employees.

The working tools of "incentive management" are the functions of standardization, materials handling, job evaluation, methods analysis, motion and time study, plant layout, and incentives. Incentives constitute the motivating medium through which management may obtain maximum utility from the various industrial engineering functions.

The incentive may appear in various forms. Although its presence is often evidenced by a financial incentive plan, this is not an absolute requisite. True, it has obtained great popularity in various fields. In contrast, it is strongly opposed by many labor organizations.

Properly and fairly administered, in combination with active management participation, it can have a beneficial effect on productivity. Management must be constantly aware of the increased "overhead" costs occasioned by the administration of a financial incentive plan. A periodic comparison should be made between administrative costs and productivity savings in order to arrive at the net savings figure for the particular plan adopted. This comparison may be presented in graphic form by a simple break-even chart similar to those introduced in Chapter I.

Management must remember that regardless of their form incentives are the potential force which obtains group co-operation in maintaining high levels of productivity. Management is the co-ordinating force for this co-operative activity. It achieves this coordination by providing the foundations for the increased productivity and also the "spirit" or leadership which gives the plan impetus and direction. By themselves, the techniques of industrial engineering have a limited scope and consequently can achieve limited results. Welded together by effective management, the "whole is greater than the parts."

Financial incentive plans, in particular, pose additional problems to management. Foremost among these is the degree to which the employees should participate in the

benefits of the plan. Bland statements are often made that the employee will be returned the full results of his increased production. He will receive 100 per cent of the savings. This is often accomplished by giving him a one per cent raise in salary for each one percent raise in production. Such limited method ignores the fact that there are two principal types of savings achieved through a financial incentive plan. They are direct and indirect savings.

Under certain industrial conditions the opportunity to share in indirect savings can be a potent force in deciding employee participation. Likewise, the degree of management and owner contribution must be evaluated. Labor's share of the increased productivity is the incentive wage. Management's and the owner's share should be in increased net profits. Exactly, what management's contributions are is often difficult to determine. Due consideration must be given to any additional investment in extra facilities and methods provided by owners and the rise in administrative costs. A balance must then be determined between employee, management and owner returns and their relative contributions.

Most incentive plans to date have been installed with insufficient analysis of actual costs and individual contributions by employees, management, and owners. Perhaps this

has occasioned the excessive number of failures of such systems. A wage incentive plan must be tailored to the individual company within its industry. High fixed investment charges which would result in increased productivity and considerable savings in one plant in a certain area or in one industry, would not necessarily be equally effective in another. Examples of such diverse conditions would be found in comparing the steel industry and its heavy investment per worker with the clothing industry. The incentive wage plan should also be tailored to meet special personnel conditions such as assimilating a constant influx of new employees.

Although this thesis has dealt primarily with incentives for production workers, there are various incentive plans or bonus plans for the white collar workers and the various other employee groups. Stock sharing plans have been set up by many companies for their executives. Bonus plans for inspectors, material handlers, and other indirect workers are common. Profit sharing plans have been successful in many cases. They have, however, the disadvantage of making the worker's wages depend upon the degree of success of the enterprise rather than his individual effort. Consequently daily productivity is not influenced greatly under most of these plans.

Group incentives are a divergence from the idea of individual incentives. Many of the same financial incentive plans are used for groups and productivity is measured in terms of the sum total of the members individual productivity. Such plans are used where it is inadvisable or impossible to use an individual incentive plan.

To conclude, any incentive plan, financial or otherwise, must have the whole-hearted co-operation of management to succeed. This means that management must contribute its share to productivity, primarily through the industrial engineering practices presented here, otherwise success of a long range nature cannot be assured for any incentive plan.

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Appendix

FUNDAMENTAL CONCEPTS AND DEFINITIONS:¹(1) Manufacturing Enterprise as a Machine

A properly designed manufacturing enterprise functions as a gigantic machine into which are fed certain raw or partly fabricated materials (having definite economic value) which are transformed into some economic good which possesses a greater economic value than the mere sum of previous economic values of the materials used, the energy consumed, the labor employed, the rent paid, and other subsidiary factors.

(2) Objective of a Manufacturing Enterprise

To create "economic goods" as distinguished from "free Goods" in a manner which enhances the economic value of the "product" over the mere sum of the economic value of the ingredients.

(3) Gross Sales

The total, annual dollar value of goods (or services) produced and sold by the manufacturing enterprise before deducting returns (e.g., due to defective goods) and allowances (e.g., permitted shrinkage, breakage, or other loss in handling or using).

The gross sales figure does not include trade discounts, sales taxes, excise taxes based on sales, and cash discounts.

(4) Net Sales

The actual, annual dollar value of goods (or services) produced as evidenced by the moneys actually received from the customers; or "gross sales" less "returns" and "allowances", freight-out, and less cash discounts.

(5) Gross Profit

An old commercial concept of "profit" as revenue due to entrepreneur's activities of selling and administration, currently defined as the difference between Net Sales and

1. Primarily a compilation of material assembled by the Industrial Engineering Department, Montana State College.

Cost of goods sold, but not including the selling and administrative expenses.

(6) Net Profit (Also known as Net Income)

The difference between "revenue" and the "sum of all operating costs" of a commercial or an industrial enterprise.

(7) Operating Profit (also known as Net Operating Profit)

The degree of economic success "achieved" by a manufacturing enterprise in raising the economic value of its product above the simple sum of the economic values of the ingredients (factors of production).

(8) Asset

In the design and operation of a "manufacturing establishment" the industrial engineer assigns the following meaning to this term.

1. An "asset" is any "owned" physical object (tangible) or a "right" (intangible) having money value to the owner of the establishment.

If there are several owners, then they must be considered collectively, e.g., a "corporation", a "city", a "state", "the government".

(9) Current Asset

Cash asset, and any other asset which may be converted readily into MONEY or other similarly negotiable assets. The five basic subdivisions of current assets are: (1) Cash, (2) Temporary Investments, (3) Receivables, (4) Inventory, and (5) Prepaid Expenses. To be considered "current" an asset must usually be convertible into some negotiable form within a year or so.

The exact length of time allowed for conversion of a "current" asset into CASH depends upon the risk attached to the particular form of a "current asset".

(10) Cash Asset

Money or any other asset which may be converted immediately into money without disturbing the functioning of the manufacturing enterprise.

(11) Inventory Asset

(1) Raw materials and supplies, good in process of manufacture, finished product, - on hand, in transit, in storage elsewhere, on consignment to others.

(2) Their aggregate monetary value, usually at cost or some fraction of cost.

(12) "Receivables" Asset

Usually this term refers to the sum total of amounts due from customers. (Not pertinent to the engineering operation of a manufacturing enterprise are other minor items classed under "Receivables", e.g., (1) Amounts owing from officers and employees, (2) Notes Receivables as distinguished from customer's accounts.) Also, customers installment accounts to be collected within one year are excluded from the "current-assets" unless the particular industry sanctions such practice.

(13) Fixed Asset

Is a tangible asset which is relatively difficult to convert into CASH or other readily negotiable asset. (Note: Assets impossible to convert into CASH under pressure, e.g. that from creditors, are often referred to as FROZEN ASSETS). Capital is invested into "fixed assets" to obtain the services such "fixed assets" can yield in the production of other economic goods or services.

(14) Total Liabilities

"Liabilities" of a manufacturing establishment are its obligations (commonly expressed in financial terms) to the contributors of the "assets" which make the existence and operation of the establishment possible.

Contributors of assets to any business unit are divided into two principal groups: (1) OWNERS, (2) CREDITORS (OUTSIDERS). The legal and economic concept underlying this division is that a business unit can be considered as a separate entity from its owner or owners; this condition is quite obvious in the case of the CORPORATION which is accepted as an "artificial" person in the eyes of the law.

(15) Fixed Cost

Rate of expenditure (with the year as the common time unit) toward some "factor of production", that does not vary with the volume of production. Examples: interest on

bonds; rent; property tax; depreciation.

(NOTE): Fixed costs are not fixed in the sense that they never vary; they vary, but from causes independent of the "volume of production" during the interval of the "time unit" involved in the "rate of expenditure".)

(16) Variable Cost

An "operating cost" or "operating costs" as a class that vary directly often proportionately, with production, utilization of some other measure of plant output. Typical "variable costs" directly proportional to plant output are: direct materials, direct labor, power, factory supplies, commissions on sales, depreciation - if computed on production basis - otherwise it is a fixed cost.

(17) Cost of Sales

A term used in accounting practice and means the cost of manufacturing the goods sold.

(18) Factory Expenses

Identifies that portion of overhead costs which is properly chargeable to manufacturing. (Thus factory expense would include a part of the general administrative expense, but it would not include any of the advertising expense.)

(19) The Operating Budget

Is an economic report which forecasts (attempts to predict) the probable volume of sales over a period of time (frequently for the year), together with a detailed statement of the probable expenditures of manufacturing and marketing the product. Budgets are based on records of past performances adjusted to the estimates of future requirements.

(20) Therbligs

A general term used to signify any of seventeen elementary subdivisions of a cycle of motions. The seventeen therbligs are: search, select, grasp, transport empty, transport loaded, hold, release load, position, pre-position, inspect, assemble, disassemble, use, unavoidable delay, avoidable delay, plans, and rest for overcoming fatigue.

CONSTANTS AND VARIABLES OF OPERATION
MEANINGS AND USE OF GENERAL SYMBOLS

X equals Variable Annual Production Rate, i.e., Plant Output, Units of Product per year.

X_{100} equals Annual Production Rate (Plant Output), Units/yr., at 100% Plant Capacity. (NOTE: 100% plant capacity is commonly understood to take place at 2,000 hours of operation per year for one shift. When "overtime" is employed, or "extra shifts", then the 100% plant capacity may be considered as occurring at some greater number of operating hours per year, e.g., 4,000 hours, 6,000 hours. Obviously, with fixed mechanization and fixed labor productivity the maximum plant output is reached at 8760 hours of annual operation.)

X_{BEP} equals Production Rate (Plant Output), Units/yr., at the Break Even Point.

S equals Net Sales, Dollars/yr., corresponding to any point of Plant Output of X units/yr., sold at p dollars/unit.

p equals Sales price per Unit of Product, Dollars. (NOTE: " p " is taken as constant during the fiscal period under study, e.g., one year, $\frac{1}{2}$ year, or a month.)

P equals Net Operating Profit, Dollars/yr., at any point of Plant Output of X units/yr.

T equals Tax Rate on Corporate Income, expressed as a fraction of the Net Operating Profit, e.g., 0.30.

R equals Surplus Retention (e.g., for Reinvestment), Dollars/yr.

R_p equals Surplus Profit, Dollars/yr.

D equals Average Dividends, % per year.

D_c equals Common Dividends, % per year.

D_p equals Preferred Dividends, % per year.

Q equals Net Profit $\div$ Capitalization.

C equals Total Cost of Operation, Dollars/yr., at any point of Plant output of X units/yr.

C_0 equals Total Cost of Operation, Dollars/yr., at Plant Output of Zero Units/yr.

C_{100} equals Total Cost of Operation, Dollars/yr., at 100% Plant Output of X_{100} units/yr.

C_{BEP} equals Total Cost of Operation, Dollars/yr., at the Break Even Point of Plant Output of X_{BEP} UNITS/yr.

c equals Unit Cost, Dollars/Unit of Product, at any point of Plant Output of X units/yr.

c_0 equals Unit Cost, Dollars/Unit of Product, at Plant Output of Zero Units/yr.

c_{100} equals Unit Cost, Dollars/Unit of Product, at 100% Plant Output of X_{100} units/yr.

c_{BEP} equals Unit Cost, Dollars/Unit of Product, at the Break Even Point of Plant Output of X_{BEP} units per yr.

F equals Total Fixed Cost of Operation, Dollars/yr., at any point of Plant Output of X units/yr., (NOTE: " F " is a constant during the fiscal operating year; or if this is too long a time interval, then it can be assumed as a constant during a quarter or one month.)

F_a equals Fixed Administrative Costs, Dollars/yr.

F_s equals Fixed Selling Cost, Dollars/yr.

F_d equals Fixed Depreciation Charges, Dollars/yr.

F_i equals fixed Interest Charges on Borrowed Capital, Dollars/yr. (NOTE: e.g., Interest on Bonds, Long Term Debts, Notes, etc.)

F_t equals Fixed Tax Charges, Dollars/yr., (e.g., Real Estate Taxes).

F_m equals Fixed Miscellaneous Manufacturing Costs, Dollars/yr., (e.g., Insurance, Heat, Light, etc.)

d equals Depreciation, a fraction of the First Cost of a

given asset which must be set aside annually to provide replacement funds. (Straight Line Depreciation is sufficient for estimating purposes.)

- i equals Interest Rate (average) on all Borrowed Capital, %
- b equals Constant Unitary Cost, Dollars/Unit of Product.
(NOTE: The value of " b " and its components b_m , b_i , b_f , and b_s are considered as constant per unit of product unless there has been a change in manufacturing methods during the fiscal period.)
- b_m equals Cost of Materials per Unit of product, Dollars.
- b_f equals Indirect Labor Costs plus Variable Factory Overhead/Unit product, \$
- b_s equals Constant Unitary Sales Cost, e.g., commission, Dollars/unit of Product.
- V equals (b) times (X) equals Total Variable Operating Cost, Dollars/yr., at any point of Plant Output of X units/yr.
- S_g equals Gross Sales, Dollars/yr., corresponding to any point of Plant Operation of X units/yr. sold at p dollars/unit.
- %Def. equals Percentage of Defective Units Produced annually and which are sold undetected.

SUBSCRIPTS AND SUPERSSCRIPTS

- 0 equals "At Zero Plant Output per Annum, i.e. at Zero annual Production rate."
- 100 equals "At 100% of Plant Capacity", i.e., at the Output of X_{100} units/yr. (See definition of X_{100} .)
- BEP equals "At the Break Even Point of Plant Operation", i.e., at the output of units of product at which the Net Operating Profit, P , is Zero.
- ' equals At the old design, prior to introduction of any changes or improvements.
- " equals For the New Design, after introduction of changes

or improvements.

Delta equals Increment of a Given Quantity, denotes an algebraic increase of a given function.

Literature Cited and Consulted List

- Abruzzi, Adam. 1954. TIME STUDY RATING PROCEDURES.
Journal of Industrial Engineering. Vol V, No 1,
January, 1954, pp. 5-7
- American Standards Association. 1952. AMERICAN STANDARDS
PRICE LIST.
29 pp., American Standards Association, Inc, New York.
- Alford, L. P. and Bangs, J. R. 1949. PRODUCTION HANDBOOK.
1676 pp., Ronald Press Co., New York.
- Alford, L. P. and Beatty, H. Russel. 1951. PRINCIPLES OF
INDUSTRIAL MANAGEMENT.
779 pp., Ronald Press Co., New York.
- Apple, James M. 1950. PLANT LAYOUT AND MATERIALS HANDLING.
367 pp., Ronald Press Co., New York.
- Barkin, Solomon. HUMAN AND SOCIAL IMPACT OF TECHNICAL CHANGES.
16 pp., Textile Workers Union, CIO, New York.
- Barkin, Solomon. 1950. THE TECHNICAL ENGINEERING SERVICE OF
AN AMERICAN TRADE UNION.
International Labour Review, Vol LXI, No 6, June, 1950,
pp. 1-28.
- Barkin, Solomon. 1950. A TRADE UNIONIST APPRAISES MANAGEMENT
PERSONNEL PHILOSOPHY.
Harvard Business Review, September, 1950.
- Barkin, Solomon. TRADE UNION ATTITUDES AND THEIR EFFECT
UPON PRODUCTIVITY.
20 pp., Textile Workers Union, CIO, New York.
- Barkin, Solomon. 1951. MANAGER'S ATTITUDE TOWARD WAGE
INCENTIVE SYSTEMS.
Industrial and Labor Relations Review, Vol V, No 1,
pp. 92-107.
- Barkin, Solomon. 1953. Director of Research, Textile Workers
Union, CIO. Letter to M.W. Burke.
- Barnes, Ralph M. 1949. MOTION AND TIME STUDY.
559 pp., Wiley & Sons, New York.

- Benjamin Electric Mfg. Co. 1945. AGREEMENT BETWEEN THE CO. AND LOCAL 1150, UNITED ELECTRICAL, RADIO & MACHINE WORKERS OF AMERICA.
95 pp., Benjamin Electric Mfg. Co., Des Plaines, Ill.
- Bethel, L. L., Atwater, F. S., et al. 1945. INDUSTRIAL ORGANIZATION AND MANAGEMENT.
798 pp., McGraw Hill Book Co., New York.
- Blocker, John G. 1950. ESSENTIAL OF COST ACCOUNTING.
441 pp., McGraw Hill Book Co., New York.
- Brennan, John E., Jr. 1953. Chief Standards Engineer, Yale & Towne Mfg. Co. Letter to M.W. Burke, dated March 19, 1953.
- Caldwell, J. W. 1953. THE IMPORTANCE OF ACCOUNTING IN INDUSTRIAL MANAGEMENT.
Journal of Industrial Engineering, Vol IV, No 1, February, 1953. pp. 19-21.
- Carroll, Phil. 1951. WHAT IS A MEASURE OF A FAIR DAY'S WORK?
6 pp. Twin City Society of Industrial Engineers, Minneapolis & St. Paul.
- Carroll, Phil. 1938. TIME STUDY FOR COST CONTROL.
305 pp. McGraw Hill Book Co., New York.
- Coleman, Charles. 1950. Chief Industrial Engineer, Timken-Detroit Axle Co. Letter to M.W. Burke, dated January 29, 1953.
- Committee for Economic Development. 1945. TOWARD MORE PRODUCTION, MORE JOBS AND MORE FREEDOM.
37 pp., Committee for Economic Development, New York.
- Committee for Economic Development. 1949. HOW TO RAISE REAL WAGES.
43 pp., Committee for Economic Development, New York.
- Cunningham, Henry M. and Sherman, William F. 1951. PRODUCTION OF MOTOR VEHICLES.
169 pp., McGraw Hill Book Co., New York.
- Dillard, Dudley. 1948. ECONOMICS OF JOHN MAYNARD KEYNES.
363 pp., Prentice-Hall, New York.

- Finley, G. I. 1953. Industrial Engineer, Pittsburgh Plate Glass Co. Letter to M.W. Burke dated Feb. 25, 1953.
- Funk & Wagnall. 1946. STANDARD DICTIONARY.
1309 pp., Funk & Wagnall's, New York.
- Gilbreth, F. B. and L. M. 1917. APPLIED MOTION STUDY.
220 pp., Sturgis and Walton Co., New York.
- Goodrich, B. F., Co. ESTABLISHMENT OF LABOR STANDARDS AND ADMINISTRATION OF THE WAGE INCENTIVE PLAN.
8 pp., B. F. Goodrich Co., Akron, Ohio.
- Hormel, Geo. A. & Co. 1943. THE HORMEL ANNUAL WAGE, WAGE INCENTIVE, AND JOINT EARNINGS PLANS.
13 pp., Sec. A. Hormel & Co., Austin, Minnesota.
- Jennings, Eugene E. 1954. THE VALIDITY OF BASIC ASSUMPTIONS IN MOTION AND TIME STUDY.
Journal of Industrial Engineering. Vol V, No 2, March, 1954. pp. 16-18.
- Jones, Phillip W. 1948. PRACTICAL JOB EVALUATION.
304 pp., Wiley & Sons, New York.
- Kennecott Copper Corp., Utah Refinery, Utah Copper Division. 1951. UTAH REFINERY JOB EVALUATION PROGRAM.
Kennecott Copper Corp., Salt Lake City.
- Kennedy, Van Dusen. 1945. UNION POLICY AND WAGE INCENTIVE METHODS.
260 pp., Columbia University Press, New York.
- Lincoln, James F. 1951. INCENTIVE MANAGEMENT.
280 pp., Lincoln Electric Co., Cleveland.
- Livingston, Robert T. 1949. THE ENGINEERING OF ORGANIZATION AND MANAGEMENT.
247 pp., McGraw Hill Book Co., New York.
- Louden, J. Keith. 1944. WAGE INCENTIVES.
174 pp., John Wiley & Sons, Inc., New York.
- Lytle, Charles W. 1942. WAGE INCENTIVE METHODS.
462 pp., Ronald Press, New York.
- McNaughton, W. L. 1945. INDUSTRIAL ECONOMY AND LABOR CONTROL.
273 pp., Golden State Publishers, Los Angeles.

Mill and Factory. 1948. UNION AND MANAGEMENT CO-OPERATE TO ESTABLISH AN INCENTIVE SYSTEM.

Mill and Factory, New York. (reprint).

Millett, Lee. 1952. Work Simplification Unit Supervisor, Maytag Co., Newton, Iowa. Letter to M.W. Burke dated November 7, 1952.

Minneapolis Honeywell Regulator Co., 1952. PROCESS GUIDE. 50 pp., Minneapolis Honeywell Reg. Co., Minneapolis.

Minneapolis Honeywell Regulator Co. 1951. ENGINEERING STANDARDS.

Minneapolis Honeywell Regulator Co., Minneapolis.

Minneapolis Honeywell Regulator Co. 1952. PROCESSING TIME STANDARDS MANUAL.

Minneapolis Honeywell Regulator Co., Minneapolis.

Minneapolis Honeywell Regulator Co., 1949. METHODS INSTRUCTIONS MANUAL.

Minneapolis Honeywell Regulator Co., Minneapolis.

Minnesota Mining & Mfg. Co. 1953. 3M INCENTIVE POLICIES. 19 pp., Minnesota Mining & Mfg. Co., St. Paul.

National Association of Manufacturers, Industrial Relations Department. 1946. INFORMATION BULLETINS NO'S. 1,3,5,6,15. National Association of Manufacturers, New York.

National Metal Trades Association. 1949. INDUSTRIAL RELATIONS POLICIES AND PROCEDURES BULLETINS, No. 3, Parts VI, VII. National Metal Trades Association, Chicago.

Natwick, Luch, Hallock. 1953. MAKING PAPER. 702 pp., Crown Zellerbach Corp., San Francisco.

Otis, Jay L. and Leukart, Richard H. 1948. JOB EVALUATION. 473 pp. Prentice Hall, Inc., New York.

Pike, Thomas P. 1950. INCENTIVE MANAGEMENT & PROFIT SHARING. Advanced Management, Vol XV, No 10, Oct. 1950, pp. 11-13.

Pittsburgh Plate Glass Co. PROCEDURES AND PRACTICES FOR APPLICATION AND ADMINISTRATION OF THE WAGE INCENTIVE SYSTEM. 9 pp., Pittsburgh Plate Glass Co., Pittsburgh.

- Rautenstrauch, Walter. 1941. THE DESIGN OF MANUFACTURING ENTERPRISES.
298 pp., Pitman Publishing Corp., New York.
- Reck, Dickson. 1954. THE ROLE OF COMPANY STANDARDS IN INDUSTRIAL ADMINISTRATION.
Advanced Management. Vol XIX, No 4, April, 1954, pp 19-23.
- Roberts, John W. 1952. TRENDS IN INCENTIVES FOR PRODUCTION AND MAINTENANCE EMPLOYEES.
20 pp., Albert Ramond and Associates, Chicago, Ill.
- Rolph, S. W. 1954. THE STRONG CASE FOR STANDARDIZATION OF MODERN BUSINESS REPORTS.
Advanced Management, Vol XIX, No 3, March, 1954, pp. 9-11.
- Scott, Walter D., Clothier, Robert C., and Spriegel, William R. 1949. PERSONNEL MANAGEMENT.
648 pp. McGraw Hill Book Co., Inc. New York.
- Shiskin, Boris. 1953. Director of Research, AF of L.
Letter to M.W. Burke dated February 27, 1954.
- Soldan, Harvey M. WAGE INCENTIVE PLANS AND USAGE.
An unpublished masters thesis. Columbia University, New York.
- Steel, Hoyt P. 1953. Executive Vice President, Benjamin Electric Mfg. Co. Letter to M.W. Burke dated Jan. 9, 1953.
- Stevenson, Jordan & Harrison, Inc. THE 100% ALLOWED HOUR INCENTIVE PLAN.
15 pp., Yale and Towne Mfg. Co., Stanford, Conn.
- Taylor, Frederick Winslow. 1911. SCIENTIFIC MANAGEMENT.
638 pp., Harper and Sons, New York.
- Thompson, James E. 1947. ENGINEERING ORGANIZATION AND METHODS.
337 pp. McGraw Hill Book Co., Inc., New York.
- Timken-Detroit Axle Co. OUTLINE FOR TIME STUDY COURSE.
18 pp., Timken-Detroit Axle Co., Detroit, Mich.
- U.S. Dept. of Labor, U.S. Employment Service, Occupational Analysis Section, Industrial Service Division. 1944. TRAINING AND REFERENCE MANUAL FOR JOB ANALYSIS.
Government Printing Office, Washington.

- U. S. Dept. of Labor. 1950. GUIDE FOR ANALYZING JOBS.
19 pp., Government Printing Office, Washington.
- U. S. Dept. of Labor. 1939. DICTIONARY OF OCCUPATIONAL
TITLES.
Government Printing Office, Washington.
- U. S. Dept. of Labor, Bureau of Labor Statistics. 1948.
COLLECTIVE BARGAINING PROVISIONS, INCENTIVE WAGE PROVI-
SIONS; TIME STUDIES AND STANDARDS OF PRODUCTION.
68 pp., Government Printing Office, Washington.
- U. S. Civil Service Commission, Personnel Classification
Division. 1945. POSITION CLASSIFICATION AS AN AID TO
SUPERVISION.
14 pp., Government Printing Office, Washington.
- Weinberg, Nat. 1953. Director of Research and Engineering,
UAW-CIO. Letter to M.W. Burke dated Jan. 21, 1953.
- Welsh, Edmund J. 1953. Executive Secretary, National Foundry
Ass'n. Letter to M. W. Burke dated Jan. 15, 1953.
- Yoder, Dale. 1948. PERSONNEL MANAGEMENT AND INDUSTRIAL
RELATIONS.
894 pp., Prentice-Hall, Inc., New York.

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