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Some applications of engineering valuation-industrial engineering theory to cost reduction in industry

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SOME APPLICATIONS OF ENGINEERING VALUATION-INDUSTRIAL ENGINEERING THEORY TO COST REDUCTION IN INDUSTRY

by

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I. ABSTRACT

An investigation was conducted, combining certain applications of the theory of engineering valuation and industrial engineering into an industrial training program. The program was designed especially to assist smaller industrial companies toward more effective cost reduction work. The purpose of the program was to secure company-wide cooperation in identifying and eliminating wasted costs from industrial products and processes. It had practical application to production planning and control, and to purchasing procedures. Problems of financial policy, selling methods, organizational changes within the company, methods of wage payment, and studies designed to make workers work harder were considered as outside the scope of this investigation.

The experimental procedure used to attain the objective was as follows: The personnel who could most effectively use the training were selected. Authority and responsibility of the trainees as a group was determined. Essential portions of the theory of engineering valuation and industrial engineering were selected, and parts not relevant to the accomplishment of the objective were excluded from the training program. Keeping in mind the limited facilities available

for conduct of the program in smaller companies, training aids were examined, and those which might be used effectively were selected. A training manual was developed for the guidance of the personnel participating.

The training program was experimentally tested in two industrial plants. Following completion of the tests, an evaluation of the results was undertaken, together with description of new applications which have been made since the program was completed.

It was found that smaller industrial concerns could benefit financially by use of the training program. The training could be effectively undertaken within the plant, and without the use of elaborate training aids. Personnel with widely varied training and experience backgrounds were able to effectively participate in the same training group. It appeared to act as a "catalyst" in securing improved inter-departmental cooperation by those participating, and it furnished a definite procedure which facilitated effective use of personnel in the problems investigated.

II. INTRODUCTION

The first record of man's efforts at industrial cost reduction has probably been lost in antiquity. The process of chipping stone and molding clay to make ancient records must have been very expensive in terms of time, if not in labor cost, and the resulting product both heavy and unwieldy. It should be safe to conclude that neither stone nor clay could stand competition from the lighter and relatively more durable papyrus, which could accomplish the same purpose, but do it faster, and result in a much more compact and useable record. Since then, many other innovations have appeared, the effect of their competition becoming apparent with the disappearance of products which could not compete.

> One reason, perhaps, why this is so restless and fiercely competitive an age, is that new ideas of democracy, new philosophies, and the great new mechanical inventions, have combined to unsettle the old customs and caste lines, so that everyone is urged to a remorseless effort to excell, to reach a goal which, because it is unlimited and competitive, must be beyond the strength of all but a few.[1]

Is this competition always worth-while? Perhaps not; the world might be a better place if gunpowder had never been

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[1]Dutton, H. P. Principles of Organization. First Edition. McGraw-Hill Book Company, New York. 1931. p. 207.

invented. However, if people on one side of a disagreement use it to force their will on others, the opposing group has to accept and use it, or find something more powerful, if they are to compete successfully, and survive.

More recently, with the vast expansion of our industrial machinery, attention has been directed toward industrial economy. Back in 1911, Mr. Henry R. Towne, President of the Yale and Towne Manufacturing Company, quoted from an earlier address he had made to the graduating class of Purdue University as follows:

> The dollar is the final term in almost every equation which arises in the practice of engineering in any or all of its branches. . . . In other words, the true function of the engineer is, or should be, not only to determine how physical problems may be solved, but also how they may be solved most economically. . . . Therefore the engineer is, by the nature of his vocation, an economist. His function is not only to design, but also so to design as to ensure the best economical result.[1]

Here we have one of the big problems of industry stated very lucidly nearly fifty years ago. Why is it that it has not been solved satisfactorily before this time? No doubt one main reason is to be found in the story of our technological progress during the past decades. Not many years before Mr. Towne's talk, steam winches, powering a plow, were recommended by the Royal Agricultural Society, after a test,

[1]Towne, H. R. Forward. In Taylor, F. W. Shop Management. Harper and Brothers, New York. 1911. p. 6, 7.

as being able to perform very satisfactorily both for plowing fields and trenching, and show savings of up to 85 per cent when compared with horse labor.[1] Today we would find it extremely difficult to find one of these machines outside of a museum.

But our changing technology, with the development of new and better machines, which can do more and better work in the same time, and require less and less skill from the operators, can only provide part of the answer. New materials, of uniform quality, are also being developed continually. Together with the machines, they are able to make possible ever increasing output of constantly improved products.

Our engineering technology has also been improving. Colleges and universities are constantly working to develop new and better methods to keep pace with industrial developments, and conducting research to help lead the way to greater economy. However, it has often been said that there has never been a surplus of management personnel who are effectively trained in running our industrial enterprises.

Back in 1911, Frederick W. Taylor, who is often referred to as the Father of Industrial Engineering, pointed up one of the major problems.

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[1] Appletons' Cyclopaedia of Applied Mechanics. Volume 1. D. Appleton and Company, New York. 1880. p. 8.

> Several papers have been written, describing the expedients which have been adopted and the details which have been developed under scientific management and the steps to be taken in changing from the ordinary to the scientific type. But unfortunately most of the readers of these papers have mistaken the mechanism for the true essence. Scientific management fundamentally consists of certain broad general principles, a certain philosophy, which can be applied in many ways, and a description of what any one man or men may believe to be the best mechanism for applying these general principles should in no way be confused with the principles themselves.[1]

Mr. Towne also recognized a difficulty. In speaking of the engineer he said

> The final issue of his work, in probably a majority of cases, resolves itself into a question of dollars and cents, of relative or absolute values. . . . To ensure the best results, the organization of productive labor must be directed and controlled by persons having not only good executive ability, and possessing the practical familiarity of a mechanic or engineer, with the goods produced and the processes employed, but having also, and equally, a practical knowledge of how to observe, record, analyze, and compare essential facts in relation to wages, supplies, expense accounts, and all else that enters into or affects the economy of production and the cost of the product.[2]

How many members of management can fulfill all that is being asked of them? Probably not as many as modern industry would desire. The tendency has been to encourage speciali-zation in training, and to have each person concentrate his

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[1]Taylor, F. W. The Principles of Scientific Management. Harper and Brothers, New York. 1911. p. 28, 29.

[2]Towne, op. cit., p. 5, 6.

attention upon a single leading function. How then can we effectively expect anyone to understand the true essence of Taylor's scientific management and at the same time fulfill the requirements set forth above?

As it relates to cost reduction in industry to date, the tendency has been to centralize responsibility for cost reduction within individual departments. Larger companies, employing many workers are generally able to procure staff assistance from within the organization to carry on the work of cost reduction; or they may procure the services of outside technical experts, usually on a consulting basis, to furnish the same service. At times these experts have generously dedicated their programs to the public by publishing complete information about them. More often, we find that publication is incomplete or delayed, or is withheld completely. This is particularly true when the purpose of the research is to improve the company's competitive position in the industry. Here immediate publication would defeat that purpose.

Smaller companies often find themselves at a disadvantage in this respect. Their staffs are not large enough to allow individuals to spend much time away from current production problems. Here too, the addition of a technically skilled man is hard to justify on a permanent basis; besides, the proportionate increase in cost is much greater for the smaller companies if they use consulting services or hire additional staff. Therefore, many of these smaller companies are unable to compete for business to the extent they would like to.

While it is probably true that the same principles will apply to all sizes of business organizations, this research is directed specifically to assist the smaller industrial companies with a program of effective cost reduction.

III. REVIEW OF LITERATURE

Cost reduction, or the elimination of wasted costs from production, has long been one of the goals of industry. Back in Taylor's[1] time, the cost of labor averaged $1.15 per day for an unskilled workman. Recent published reports of the Bureau of Labor Statistics[2] showed that the modern workingman of the same classification received more than that amount per hour. Therefore, it was not surprising to find that a great deal of attention has been directed specifically toward the reduction of labor cost. Taylor's approach may even have been termed progressive for his time.

> The writer has already indicated that he thinks the first object in management is to unite high wages with a low labor cost. He believes that this object can be most easily attained by the applications of the following principles:
> (a) A Large Daily Task.
> (b) Standard Conditions.
> (c) High Pay for Success.
> (d) Loss in Case of Failure.
> When an establishment has reached an advanced state of organization, in many cases a fifth element should be added, namely: the task should be made so difficult that it can only be accomplished by a first-class man.[3]

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[1]Taylor, op. cit., p. 47.

[2]U. S. Department of Labor, Bureau of Labor Statistics. Monthly Labor Review. Wage Chronology No. 3. United States Steel Corporation. Vol. 72. No. 5. May, 1951. p. 563.

[3]Taylor, F. W. Shop Management. Harper and Brothers, New York. 1911. p. 63, 64.

Taylor set out to accomplish this purpose by experimenting to determine "what really constituted a full-day's work for a first-class man; the best day's work that a man could properly do, year in and year out, and still thrive under."[1] That he was successful in reducing labor cost is attested to in the record of the third year of working under the plan, when labor costs dropped to less than one-half of the old cost.[2]

Taylor didn't stop at this point. He felt that there must be some definite, clear-cut law as to the amount of work a first-class laborer could do. After three series of experiments, the data was given to Mr. Carl G. Barth for analysis and interpretation.

> In a comparatively short time Mr. Barth had discovered the law governing the tiring effect of heavy labor on a first-class man. . . . The law is confined to that class of work in which the limit of a man's capacity is reached because he is tired out. . . . for each given pull or push on the man's arms it is possible for the workman to be under load for only a definite percentage of the day. . . . as the load becomes lighter, the percentage of the day under which the man can remain under load increases.[3]

During this interval, the techniques of securing effective stop-watch studies in the measurement of performance were improved both in method and in precision of measurement.

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[1]Taylor, F. W. Principles of Scientific Management. p. 55.

[2]Ibid., p. 71.

[3]Ibid., p. 57.

Others, not directly connected with Taylor or the Taylor Society became interested in his method and the spectacular results which had been achieved. Taylor cautioned them repeatedly.

> The knowledge obtained from accurate time study, for example, is a powerful implement, and can be used, in one case to promote harmony between the workmen and the management, by gradually educating, training, and leading the workmen into new and better methods of doing the work, or, in the other case, it may be used more or less as a club to drive the workmen into doing a larger day's work for approximately the same pay that they received in the past.[1]

More particularly he cited an example of what had happened when his advice was ignored.

> Several men who lacked the extended experience which is required to change without danger of strikes, or without interference with the success of the business, from the management of "initiative and incentive" to scientific management, attempted rapidly to increase the output in quite an elaborate establishment, employing between three thousand and four thousand men. Those who undertook to make this change were men of unusual ability, and were at the same time enthusiasts and I think had the interests of the workmen truly at heart. They were, however, warned by the writer, before starting, that they must go exceedingly slowly, and that the work of making the change in this establishment could not be done in less than from three to five years. This warning they entirely disregarded. They evidently believed that by using much of the mechanism of scientific management, . . . that they could do, in a year or two, what had been proved in the past to require at least double this time. . . . The result of all this disregard of fundamental principles was a series of strikes, followed by the downfall of the

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[1] Ibid., p. 133, 134.

> men who attempted to make the change, and by a return to conditions throughout the establishment far worse than those which existed before the effort was made.[1]

As might be expected, those failures were given wide publicity, and while the persons responsible had acted contrary to the principles set forth, inevitably the whole field of standards determination fell into disrepute, each succeeding misapplication of the techniques increasing resentment against them until there were left only a few to carry on the work. It has only been during the last decade that time study has again returned to a position of general respect in production and cost reduction work in industrial society.

One of the early associates of Mr. Taylor was Frank Gilbreth. While Mr. Gilbreth apparently felt no conflict between his and Mr. Taylor's ideas, his approach to the problem was quite different. For a number of years he was a building contractor, specializing in brick work. During this period many bricklayers were immigrating to this country from various European countries, and Gilbreth observed that the methods they used in laying brick varied considerably, and that the productivity of the men also varied. He set out to find the one best way to lay brick, operating on the theory

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[1] Ibid., p. 133, 134.

that if the workman is busy, and if he uses no waste motions, his productivity will naturally increase. He felt that the studies conducted in this field were "but the beginning of an era of motion study, that will eventually affect all of our methods of teaching trades."[1] His advice in the teaching of apprentices was very direct and to the point. "Teach them to make absolutely no motions and to have their hands travel no distance that does not give results."[2]

Later Mr. Gilbreth, together with his wife, Lillian M. Gilbreth, did extensive work in the general development of motion study, defining it as:

> Motion Study consists of dividing work into most fundamental elements possible; studying these elements separately and in relation to one another; and from these studied elements when timed, building methods of least waste.[3]

The results of these investigations were summarized in the therblig form of elemental analysis developed from micro-motion analysis, which is familiar to all students of the subject. Here the cleavage from Taylor's time study is more definite. However, when one remembers that Taylor's goal was to find out the time it ought to take a workman to do a job, the differences are not contradictory. Fortunately, the same

[1] Gilbreth, F. B. Bricklaying System. The Myron C. Clark Publishing Co., New York. 1909. p. 140.

[2] Ibid., p. 160.

[3] Gilbreth, F. B. and L. M. Applied Motion Study. p. 43. Original not available for examination; cited in Morrow, R. L. Time Study and Motion Economy. The Ronald Press, New York. 1946. p. 10.

stigma which troubled Taylor and his associates was never applied to the Gilbreths' motion study and micro-motion study, so progress in productivity did not suffer.

Many others since Taylor and Gilbreth have done much to advance the science of increasing and measuring productivity. Their works have been too numerous to examine in detail. However, there has been one major improvement which deserves attention. Several groups of analysts, the latest being Maynard, Stegemerten, and Schwab have carried the development one step farther, and have set standards for normal performance for the very short elements that make up human motions.[1] The approaches used by the different groups varied, and the elemental breakdown of the motions also varied; but they all had one thing in common, that being to provide a yardstick by which the most economical motion pattern could be determined, and equitable production standards set. The end result was to increase productivity and reduce labor costs. In Methods-Time Measurement the reader is cautioned:

> Experience has demonstrated that if sufficient analysis and study are devoted to any given job, the method for doing it can usually be improved, at least until the point of fully automatic operation is reached. In order to be profitable, however, the cost of the study must not exceed the savings that result. Therefore, it is important for the

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[1]Maynard, H. B., Stegemerten, G. J., Schwab, J. L. Methods-Time Measurement. First Edition. McGraw-Hill Book Company, Inc., New York. 1948.

> methods engineer to regulate his work so that, as nearly as possible, he devotes sufficient time to any study to obtain as great savings as possible, and yet not so much time that there is no net saving after the cost of making the study has been defrayed.[1]

Various formulas have been developed by different authors to serve as a guide toward the economical operation of this function in an industrial concern. However, the main purpose and emphasis is to operate from a departmental or staff functional basis and train individuals in the techniques of methods improvement.

In most cases it is recognized that there must be liaison with other departments and units in the company if the improved methods are to work in practice, but the responsibility and initiative have largely been kept centralized in one section, the methods section.

> In order to determine which method of all of those available is the most economical, three major factors must be taken into consideration. These are 1. Machine cost. 2. Tool cost. 3. Labor cost. Other factors also enter in, such as floor space occupied, power consumed, material used, etc. In most cases, however, they are so similar for different methods that they may be neglected. If in special cases they differ enough to justify inclusion in the analysis, they may be included in the formula for the determination of the most economical method.[2]

Where the purpose is to improve methods, any changes in material or design become, in a sense, obstructions to

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[1]Ibid., p. 195.

[2]Ibid., p. 201.

standardization. However, for the company as a whole, economy in material is probably as important as economy in method. Many companies have paid close attention to material cost, especially during periods of material shortages and controls such as we have been experiencing for the past decade.

> The General Electric Company has set up a "Value Analysis Division" of the purchasing function to work with vendors as well as with G.E.'s own manufacturing and engineering personnel in the study of existing and new products. Ways are sought to lower costs through the elimination, alteration, or simplification of purchased parts or material items.[1]

Here the initiative was taken by the purchasing department in attempting to do their part toward economical operation. An investigation of the program initiated there in 1947 revealed that effective cooperation between different divisions of the company has been developed which crosses department and divisional lines quite effectively.

> It is obvious that teamwork is absolutely essential. This is not conference or committee work, but a highly individualized responsibility. The value analyst works directly with the responsible engineer on items of engineering evaluation or other engineering problems. He works directly with the responsible manufacturing men on materials, on forms of raw material, on fabricating problems. He is constantly working with the

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[1] Bethel, L. L. and others. Industrial Organization and Management. Second Edition. McGraw-Hill Book Company, Inc., New York. 1950. p. 262.

> buyer, making sure that each element of value is realized in the purchasing arrangements.[1]

Here coordination between departments in the company was effected for the purpose of improving the value-cost relationship, by a specialist, trained to serve each of the divisions, who suggested changes where improvements might be expected. Indeed, there was some precedent to justify this expansion of activities between the purchasing department and engineering.

> There is a blurred line between the responsibility of the purchasing department for materials-quality standards and that of the engineering department concerned.[2]

This expansion and interest in value may well have been an outgrowth of the development of the field of Engineering Valuation. Valuation probably had its beginnings in the general field of appraisal for tax and other purposes. However, valuation as used here carried a different meaning.

> "valuation" is a process of estimating future worth, and should be distinguished from "appraisal," an estimate of actual worth for the purposes of taxation or insurance. Valuation is the answer to the question "will it pay?" which invariably arises at once in any discussion of a new project to satisfy a human need.[3]

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[1]Value Analysis. Purchasing Magazine, June, 1950. Original not available for examination. Read in reprint only.

[2]Bethel, op. cit., p. 262.

[3]Hoover, T. J. The Economics of Mining. Stanford University Press. Stanford University, California. 1933. p. 9.

Marston and Agg[1] set forth the fundamental basis of value as the present worth of future net returns. The difference here was the addition of a compound interest factor which discounted future returns to the present time. This was also the subject of extended analysis by both Grant[2] and Thuesen[3] in their texts on engineering economy. Where economic alternatives needed to be compared in order to determine which would cost the least for equivalent value, a common basis of comparison was essential, taking into account the time cost of money. Hoover emphasized the importance of accuracy and completeness in these calculations.

> The past is strewn with glaring mistakes in estimating engineering projects as a result of not applying the engineering method with care and discernment. Of many of its past performances in this regard the profession has no cause to be proud; far too many underestimates have been made on future capital requirements and probable costs of operation, as well as overestimates of probable revenues; nor have the sequelae of overproduction been given due forethought. In every case the mistake lay, not in the method itself, but in its application. And the errors do not so much occur in determining strength of structures or the capacity of machines, as in a lack of understanding of economic factors. . . . The engineer

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[1]Marston, A., and Agg, T. R. Engineering Valuation. First Edition. McGraw-Hill Book Company, Inc. New York. 1936. p. 6.

[2]Grant, E. L. Principles of Engineering Economy, Third Edition. The Ronald Press Company, New York. 1950.

[3]Thuesen, H. G. Engineering Economy. Prentice-Hall, Inc., New York. 1950.

> has yet much to learn concerning financial and social planning, but he would seem to be in a position at the present time, by education and experience, to become probably the most powerful unit for human betterment.[1]

Much of the literature of Engineering Valuation was devoted to problems of estimating the probable lives of various classes of equipment under varying service conditions. Also, as depreciation became an important source of expense deduction for tax purposes, much work was done to develop satisfactory methods for depreciating groups of similar units, as well as individual units of property. Added impetus was given to this phase of valuation with the codification of Internal Revenue Bureau policies, requiring systematic accumulation of evidence to support claims for depreciation based upon average lives of equipment different from those set forth in Bulletin F.[2] In recent years, due primarily to the requirements of State and national utility commissions, public utilities have done much developmental work and cooperated in evaluating various theories upon which to base depreciation estimates.

The Iowa Engineering Experiment Station sponsored a number of studies designed to further develop and to clarify

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[1] Hoover, op. cit., p. 14.

[2] U. S. Bureau of Internal Revenue. Income Tax Depreciation and Obsolescence. Estimated Useful Lives and Depreciation Rates. Revised January 1942. U. S. Treasury Department. Bulletin "F". U. S. Government Printing Office, Washington, D. C. 1948.

understanding of the various systems of depreciation, with application to both industrial and public utility property. Prior to that time, understanding of the importance of depreciation in the industrial sense had not been very general.

> Production equipment undergoes very rapid and continuous improvement in quality and material changes in capacity and is continued in service or removed from service in accordance with economic conditions or management policies rather than because of its physical condition. Furthermore, in the case of certain equipment, maintenance practice affects greatly the average life realized, and, therefore, the experience of one company may be greatly different from that of another similar organization.[1]

In particular, there has been little understanding of problems relating to group depreciation of property. Winfrey's analysis of this branch of depreciation accomplished a great deal toward the clarification of this subject.[2]

When companies have felt the need for assistance in handling technical problems such as those outlined in the preceding pages, their recourse has been either to hire someone already qualified in that particular field or to call upon consultants for specialized assistance. In the latter

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[1] Winfrey, R. Statistical Analyses of Industrial Property Retirements. Iowa State College, Engineering Experiment Station Bulletin 125. 1935. p. 9.

[2] Winfrey, R. Depreciation of Group Properties. Iowa State College. Engineering Experiment Station Bulletin 155. 1942.

case, the recommendation has often been to send selected personnel to specialized schools, or to conduct training programs within the company for personnel who are directly concerned with the problem.

These industrial training programs for the purpose of cost reduction have been held in many plants for many years. In some, the general plan has been to avoid formalizing them by the inclusion of the term training program, while in other organizations, the formalized training program has become as common as indoctrination procedures for new employees. However, it appeared that the general tendency in either case has been to restrict each program to the training of personnel in some specific technique to take care of a particular problem. The titles of some of those training programs examined were quite revealing.

"The How Book of Cost Cutting Material Handling."

"How to Set Up a Program for Motion Economy."

"Foreman Training - Cost Reduction Thru Better Methods."

"MTM Instruction Manual."

"Industrial Engineering Cost Reduction Conferences."

"Foremen's Time Study Manual."

"Work Simplification."

"Job Training Manual."

Undoubtedly these training programs have been very successful in accomplishing their stated purposes. In the introductions to many of these programs a statement similar to the following could be found.

> In the past, progress in cutting production costs has been limited largely to improved mechanization of specific processing operations. But now industry must look elsewhere for additional production savings to meet intense competition in broadened markets and still provide an equitable return on invested capital.[1]

Following the statement of the general conditions, a tie-in with the specific problem was usually to be found.

> Generally speaking, plant operators have been engrossed in the job of perfecting processing techniques. Few realize a material handling problem exists in their plants, or at least that it is a high cost factor. Only in isolated cases have men been given the responsibility for finding ways to cut the cost of handling materials. . . . It's your money! You want to get the fullest value out of each material-handling dollar. The question is "HOW?"[2]

In another training program the following was found.

> Today's profits will not come from lower materials costs. They will not come from lower labor costs. They will come from increased operating efficiency.[3]

In these and in other training programs, the emphasis appeared to be to train a specialized group of workers or supervisors in the working of some particular technique of

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[1]The How Book of Cost Cutting Material Handling. The Yale and Towne Manufacturing Company, Philadelphia, Pennsylvania. 1946. p. 3.

[2]Ibid., p. 3.

[3]Mogensen, A. H. How to Set Up a Program for Motion Economy. Factory Management and Maintenance. Vol. 93, No. 11. November, 1935. p. s-133.

management. In two of the programs there was an apparent effort made to encompass company-wide participation. In one of these,[1] the two main headings in the section devoted to cost reduction were listed as "Ineffective Supervisory Methods" and "Indifferent Attitude". This could lead one to believe that the approach used was more a study of mental states and processes than a direct study of economy and cost reduction.

The other was the purchasing value analysis program of the General Electric Company. Here the training was highly specialized, primarily being given to groups of buyers. Presentation to personnel in other departments was restricted to informational demonstrations to acquaint them with the idea, with the hope that operating departments would request value analysis aid when they recognized the need. However, an additional feature of this plan was to make possible valuations of products while they were still in the planning stage. This seemed to be a significant contribution.

It appeared that much has been done through all of these training programs to acquaint industry with different methods of cost reduction. Theories and procedures have been outlined for a great many applications. No one program could, in a practical sense, offer technical training to all men,

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[1]Maytag Management Development Program. VocaFilm Corp., 424 Madison Avenue, New York. 1948.

each for proficiency in his special function.

In the smaller companies each of the respective functions are normally handled by one individual. These men are probably well qualified in their own specialties. Is there anything else that might be developed which could make their combined efforts more effective in the field of company-wide cost reduction?

It is felt that all operating and management personnel could benefit from training in the identification of all forms of wasted cost, and their measurement or estimation. Also, that as a group, they would welcome a simplified procedure for coordinating each person's efforts toward utilizing the special skills he has, in order to secure for the company maximum value for each element of cost.

It is hoped that the training program which has been developed as a result of this investigation will aid industry in the field of cost reduction.

IV. PROCEDURE

The first problem in the development of a practical industrial training program in cost reduction was to determine its objective. "Most economical cost" here means maximization of profits to the company. Each company has as its main objective the production of its products at the most economical cost. Likewise, each division or department within a company also has as an objective the accomplishment of its share of the production at the most economical cost. It was essential that the program, as developed, assist in the attainment of those objectives. The successive steps in its development follow. They are described in detail in the sections following.

(1) Personnel to be trained.

(2) Their authority and responsibility.

(3) Content of the program.

(4) Selection of training aids.

(5) Location and time required for training.

(6) Development of the training manual.

(7) Selection of the company to test the program.

(8) Experimental testing of the training program.

A. Personnel To Be Trained

It would not be possible for each individual in a company to attend a training program such as this. Therefore, one of the first requirements was to select the personnel who could most effectively make use of the training. Since this program was designed particularly to help smaller companies, selection of personnel to be trained was greatly simplified. In cost reduction work, primary sources of savings in cost, or in the elimination of wasted cost, would be from improvements in materials and methods, design economies, and from improvement in the coordination and control of production. Personnel from these departments who would most likely be affected would be (1) the purchasing agent, (2) the methods or time standards man, (3) the chief designer or engineer, and (4) the superintendent of production. A fifth member necessary for the proper functioning of this group would be a representative from the cost accounting department. The results of this committee's efforts would require translation of all costs into dollars and cents for examination, comparison, and recommendation or decision.

B. Their Authority and Responsibility

The degree of authority and responsibility which would reasonably be assigned to those participating needed to be determined. Most of the personnel listed above, as individuals in responsible charge of different functions in the company, are normally given a sufficient measure of responsibility together with authority to accomplish their work. It may be assumed that the exercise of their normal levels of authority and responsibility would function just as effectively in formal cooperation with the others in the group, and that decisions which they would normally make could be made just as effectively in this instance. Where they would usually make recommendations individually to top management for decision, they could continue the procedure as a group, and perhaps, lighten management's task in coordinating and resolving any difference of opinion which might appear in the committee.

> The committee, if experienced, can function almost as a single greater mind in visualizing and exploring all the facts of a complex situation. To function thus, however, its members must be capable of understanding one another's viewpoints and problems. . . . This presence of different ideas and experience backgrounds may make a suitably organized committee particularly effective in an inventive capacity. For the likelihood of productive combinations of ideas is increased, when men of different experiences and habits of thought exchange ideas. One man makes

> a suggestion, which is taken up and given the right twist by another. Neither could have produced the result alone. For this reason, among others, research groups find periodical meetings for discussion useful, and industrial engineers customarily hold staff discussions of important reports and recommendations to clients.[1]

If the above trainees, as a group, receive uniform training in the identification of all forms of wasted cost, they should improve their contributions both in quality and quantity in the solution of cost problems, particularly those involving more than one department.

C. Content of the Program

The next factor for consideration was determination of the amount of engineering valuation and industrial engineering theory which should be included in this training program. The main requirement would be to assure that all essential portions of theory were included, and at the same time to omit any portion of theory not relevant to the accomplishment of the stated objective. It could be assumed that each of the individuals participating was skilled in the theory and techniques of his special function. Therefore, the program did not include any training intended for individual members of the group.

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[1] Dutton, op. cit., p. 225, 226.

There have been many special developments in engineering valuation theory. Some of them were quite complex in operation. For example, a great deal of work has been done in the development of different methods of depreciating group properties. If, in this training program, savings might be realized from the replacement of any one unit in such a group, those same savings could normally be applied to each additional unit in the group. Therefore, for the purpose of cost reduction in production, the development of group depreciation theory for accounting purposes would not be necessary.

However, one of the more important costs of production was the depreciation cost of tools and equipment, particularly for special tools such as dies, jigs, and fixtures. A proper understanding of what depreciation means and how it should be computed was essential if costs are to be determined.

It was equally essential that each member of the group have a clear understanding of common methods for making cost comparisons between alternatives. Since the basis for recommendation and action arose from the choice of the most economical alternative, it was necessary that the group be able to convert cost figures from the form in which they were originally found to one which would permit equitable comparison. Capital gains and sunk costs have frequently been included in cost comparisons. Neither of them had any bearing on production cost. It was desirable that the group understand what each of them was, and how to measure and eliminate them from cost comparisons.

It was probable that not all members of the training group would have had training in estimating costs. Some costs were determinable. Many others, such as depreciation and overhead, had to be estimated. In order to have as accurate costs as possible, systematic means of estimating should be included in the training program.

If the group was to be effective in its work, it was essential that they have a definite procedure for investigating problems and initiating action. This should not be in conflict with any normal procedures which were in operation in the company, but should supplement and facilitate use of existing forms.

The field of application of this training program should be broad enough to make it effective in improving the handling of business crises brought on by production problems where immediate action is required. It should also apply equally well to routine problems, the solution of which might well prevent the occurrence of future production crises. Planning future production presents many problems. If planning is to be made more effective, this training should improve the efficiency of the trainees in recommending action.

D. Selection of Training Aids

The variety and kinds of training aids which might be used to an advantage in this program was another problem which was considered. Most of the other training programs, listed on page 21, emphasized the desirability of using as many training aids as possible. Special mention of motion picture film, film slides, charts, graphs, and other visual aids was made, with a general recommendation that as many of them as possible be utilized. Most of these training programs had been developed for large companies. Would these same training aids be desirable or useful for training programs in smaller concerns? Small companies usually have a limited budget for training purposes. Perhaps it would be possible to present an effective training program without the use of high-priced visual aids. An additional reason for omitting elaborate visual aids was that on previous visits to companies of this type, no facilities had been seen which could readily be adapted to requirements for showing film. Perhaps a training manual could be developed which would effectively explain the material to be covered, without recourse to expensive visual aids. Therefore, the training aids developed for this program were (1) a training manual for each of the trainees and (2) a small combination blackboard and paper pad, 18 inches by 24 inches, which could be mounted on a platform rigidly fixed to a photographic tripod.

See Figure 1. This permitted adjustment in the height of the writing surface, enabling the instructor to work at it in either a standing or sitting position. The blackboard was designed for use when no record of the graphic work or calculations was necessary. The pad was to be used when later reference to illustrations and calculations would be desirable.

In lieu of other kinds of training aids, it was felt that the participants in the training program would prefer to work on problems with which they were all familiar. Therefore, it was planned that each member of the group be encouraged to suggest various problems for group practice, and to bring the product or part into the training session where it would be visible, and where discussion could be more readily directed to each of its features as value-cost aspects of it were examined. This should prove to be a very effective way to stimulate group participation.

E. Location and Time Required For Training

A decision needed to be made as to where the training should be done. Some of the programs previously mentioned included a recommendation that the training would be much more effective if it could be completed away from the factory. Others recommended on-the-job training as the more desirable

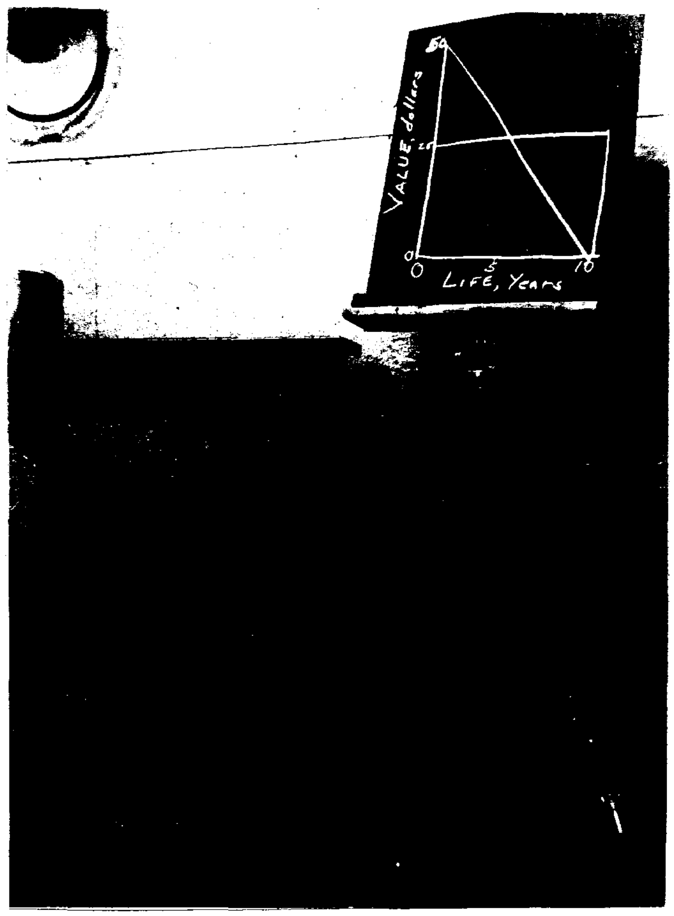

Figure 1. Portable blackboard mounted on camera tripod.

method. In this case, considering the availability of personnel who would take part, it seemed essential that the program be designed for presentation in the factory, but in a separate room.

In a small industrial concern it would be difficult to arrange to have all of the trainees absent from their regular work for too long at any one time, or for too much of any one work week. Therefore, in order to make it possible for each of the above individuals to take part in the training program it was necessary to keep the total length of training, and the length of each individual period, to a minimum. The length of time for each training session would need to be long enough to permit progress in the program. The frequency of training sessions should be close enough so that the trainees would not forget portions of the program studied earlier. At the same time, all of the men would have responsibilities in their daily work which would preclude the possibility of devoting a major part of any one day or of the work week to the training program. It was felt that two-hour sessions, occurring not more than three times a week, would be most effective.

F. Development of the Training Manual

Development of the training manual to be used by participants in the program presented a problem not commonly found in thesis literature. Each member of the group would have different skills as a result of his previous training and experience. However, some of the trainees would be engineers, with highly technical training in that field. Others would have a background more closely allied with the field of business administration and accounting. Part of the group would probably have completed their formal training years before, and would also have a wealth of practical experience to offer.

Still others of the group would be men who had received the greater part of their education solving production problems in the shops; men who had progressed to positions of authority in the company by virtue of the respect their fellow workers had shown them over a period of years. They might have horny hands, but the practical "know-how" which they could contribute would do much to make the work of the group effective.

Since the group could be assumed to vary widely in background training and experience, it was especially desirable to word the manual in such a way that it would be easily and equally understandable to all of them. Current literature and texts were not of much use in this problem, since most articles and books implied familiarity with the meaning of specialized technical terms which might not be within the special field of one or another of the group. The manual was written and rewritten several times before the wording appeared to be satisfactory in this respect. Criticism and suggestions for improvements in the wording were solicited from several staff members before it was experimentally tested in industry. It was also planned that the personnel participating in the test be encouraged to comment on the clarity of the wording.

G. Selection of the Company to Test the Program

The next problem was the selection of a company to test the usefulness of the training program. It would be very desirable that this company be of a size such as may be found in a great many Iowa communities. The company should have a stable organization, having been in existence for a number of years. Their production should include a variety of products, at least some of which should have been produced in quantity. Personnel in the company should be considered as well trained in their individual responsibilities.

It would also be desirable for the company to currently have in production products which had not changed appreciably for a period of time, and also to be confronted with production problems on other items being manufactured. It would, of course, be necessary for the company to choose a time for the meetings so that each of the selected persons could take part in the training program.

In the development of this training program, a number of companies were considered before preliminary investigation narrowed the choice to two. One could be described as a job shop type of metal-working company. A large proportion of their business had always originated from competitive bidding for work from other companies. They produced a great variety of metal products, especially those involving forming operations. The company has been in operation for many years and has apparently enjoyed a substantially steady growth in total business throughout its life. The plant itself looked old. Most of the machinery in use was of a general purpose type, and much of it had been in service for a number of years.

The other company had not been in existence for as long a period of time but had enjoyed more rapid growth, largely accelerated by World War II conditions. The products manufactured there included both wood and metal fabrication. Part of the production was of job shop type, but the greater proportion appeared to be mass production of items for the retail trade. This company had recently purchased the business of another company which manufactured wheel barrows for home and industrial use, and they were busy integrating this new product into their production schedules. As might be expected, they were experiencing a number of production and cost problems during the process.

When the training program was described to management in these two plants, personnel from each of them requested that it be tested in their plants. Since problems in the two plants apparently were not the same, a choice between them was particularly difficult. It was therefore decided that it would be desirable to test the program in both plants, if a time for training sessions could be arranged which would not conflict. Those arrangements were completed.

H. Experimental Testing of the Training Program

In the two companies which cooperated in testing the effectiveness of the training program, meetings were scheduled on Monday, Wednesday, and Friday, for a period of three weeks during February, 1953. In one company the sessions were scheduled from 9:45 to 11:45 a.m., and in the other, from 1:15 to 3:15 p.m.

The plant and office facilities of both companies were in groups of rather old buildings. See Figure 2. Seemingly every bit of space was being used continuously. In one plant,

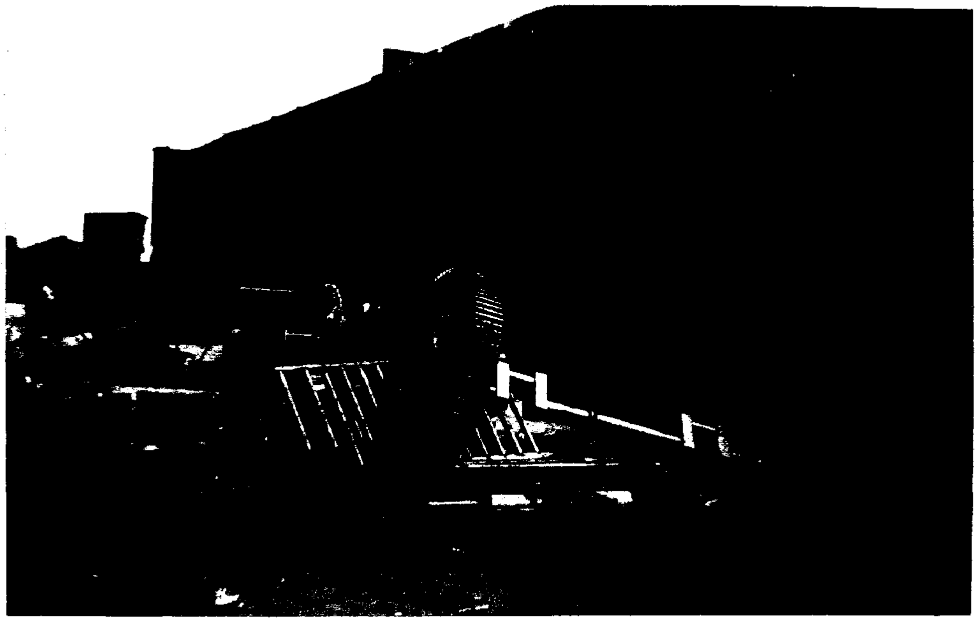

Figure 2. View of one plant showing outside storage area.

the only available space for conducting the training program was in a small lunchroom adjacent to the offices on the second floor. The training group assembled around a ping-pong table for the sessions. See Figures 3 and 4. This lunchroom was located directly over one of the larger presses on the main floor. Whenever the press was in operation, there was a noticeable vibration throughout the room. This might have seemed to be disconcerting, but the members of the group were so accustomed to the surroundings that neither the vibration nor the other features of the room appeared to distract any of them in the least. The other group met in the office of the Chief Engineer, seating themselves around his desk. There was no vibration there, but the telephone occasionally interrupted sessions. Closeness of the offices turned out to be an invitation for interruptions by all who wished to confer with any of the trainees. However, it was not a major problem, and might well be expected when representatives of so many operating departments were taken from their customary duties at one time.

Both groups had been encouraged to bring sample parts and products into the sessions to use as problems for group consideration. From the problems offered, the groups selected the ones they would like to work on first, and samples of the part or product were procured for examination and analysis.

Figure 3. Lunchroom location of one training program.

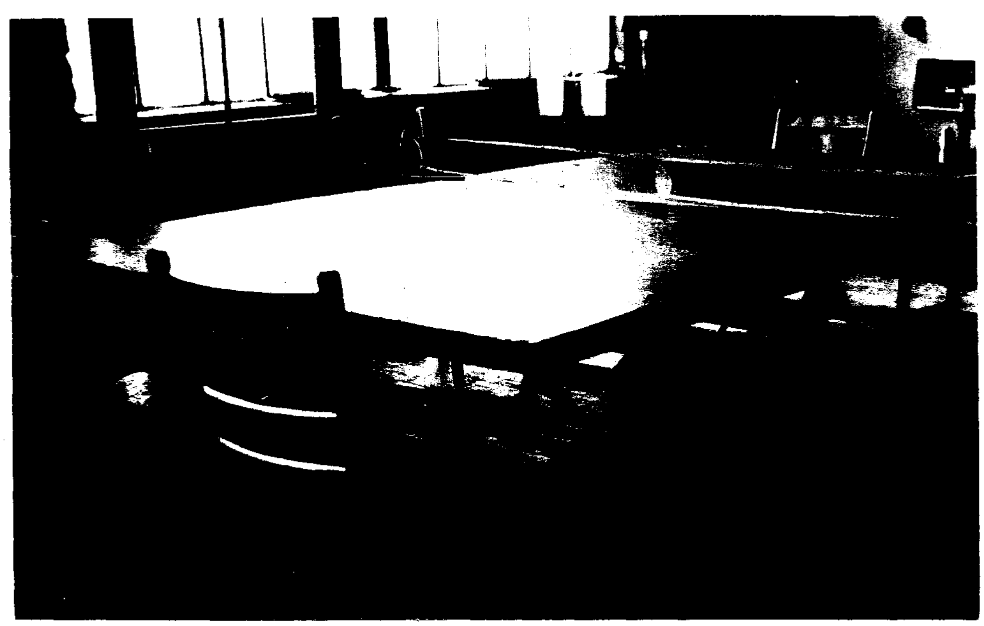

Figure 4. Ping pong table used in training.

One of the groups brought a sample Christmas tree holder into the training session to use as a problem for group consideration. See Figure 5. The group discussed its features, and began an analysis of it to determine the value which each part contributed to the product. The cost accountant brought cost records into the meeting, and value-cost comparisons were made. It happened that, at this session, the design engineer had been called away to attend a meeting with other management representatives. While he was absent, many suggestions were made of possible methods to improve the value-cost ratios of the different parts, and each of the seemingly more desirable ideas were recorded for the design engineer's comments when he returned.

As soon as he joined the group, the ideas were described to him. He immediately excused himself, and when he returned a few minutes later, his arms were full of samples of Christmas tree holders. He placed all of them on the table in front of the group, and proceeded to show that each of the ideas had been anticipated by one or another of the company's competitors. Most of them were also patented. This, of course, seemed highly discouraging. However, the important thing was that the group, made up of a methods man, a production man, a purchasing agent, and the cost accountant had, in one hour, and in a field of endeavor not usually considered

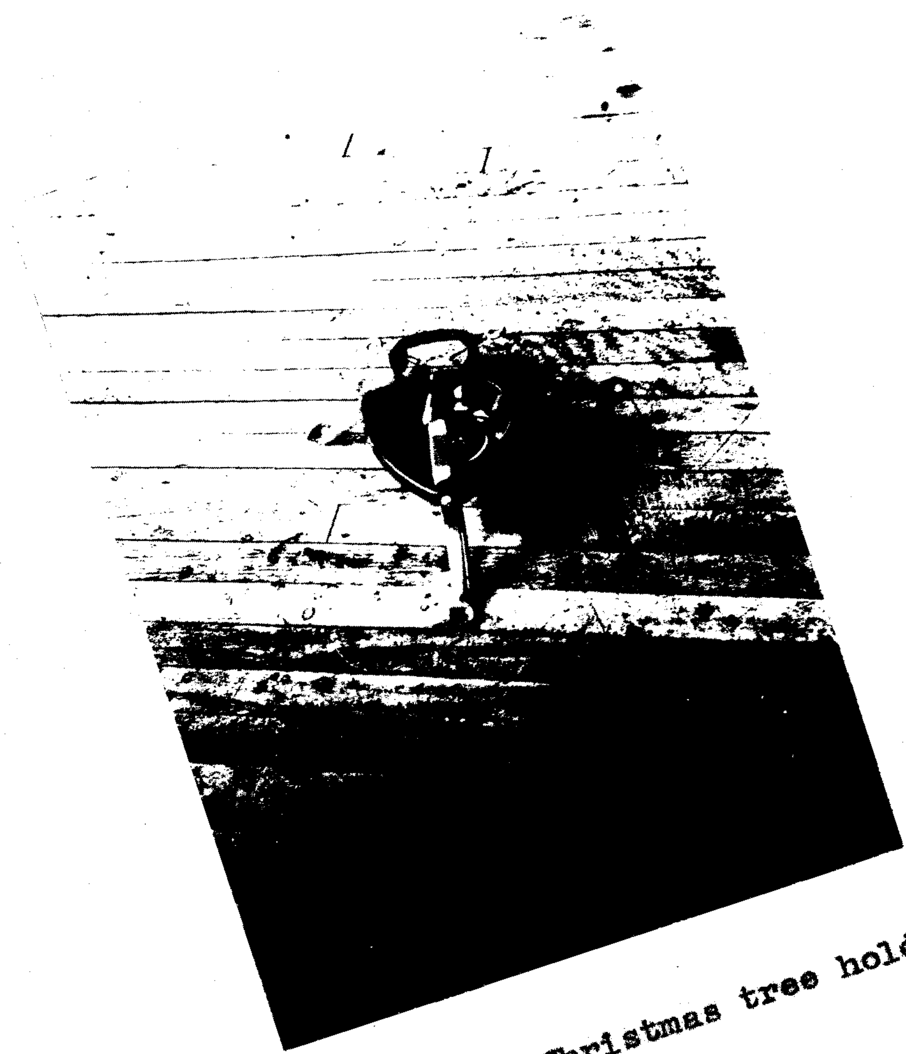

Figure 5. Present Christmas tree holder.

as being within their area of consultation, thought of and described clearly all of the ideas for economical design and production that apparently were in use in this highly competitive field. Some further discussion took place, including an enumeration of the desirable features which a Christmas tree holder should have for high value-cost relationship. Following the discussion, the matter was dropped for the remainder of the session.

Two days later, when the group again met, the first subject for discussion was the Christmas tree holder. Each member of the group had, in the intervening time, thought of some improvement which would be possible, and which apparently would not infringe upon any of the outstanding patents held by competitors. The composite result of the suggestions was a holder which seemed both feasible and economical to manufacture, and which would contain desirable features not found in any of the types currently on the market. For instance, the holder for a larger tree should have a wider base than for a smaller tree; and, at the same time, the same holder should be adjustable to varying sizes of tree diameters. A very simple but practical solution to this problem was among the ideas suggested in the group discussion.

A Christmas tree holder might seem to be a small item, but, in the aggregate, since planned production was estimated as 300,000 units for this year, the importance of even fractional penny improvements in unit cost became readily apparent. The actual comparative cost figures from this problem will not be available for some time, because contracts had already been signed, based upon the existing design; and the advertising was already distributed. However, the progress made in that one meeting toward improving the company's competitive position with respect to this product clearly illustrated the value of the program.

Another product was suggested for analysis during later sessions of the group. The company manufactures quantities of metal-frame basement windows and distributes them to a large number of customers throughout this section of the country. The design of the window itself was not considered, but comparative costs of packing and shipping groups of four of these frames were studied, with the hope that suggestions might be forthcoming which would improve the value-cost ratio. In the past, bundles were made by banding four frames together with steel bands, then shipping them by truck to the various retail outlets. See Figure 6. Quite often, the window frames would arrive at their destination with the paint scratched. While complaints had not been very frequent, the elimination of this scratching, together with the improved feeling which distributors would have toward a more attractive package for this item, was deemed desirable. An

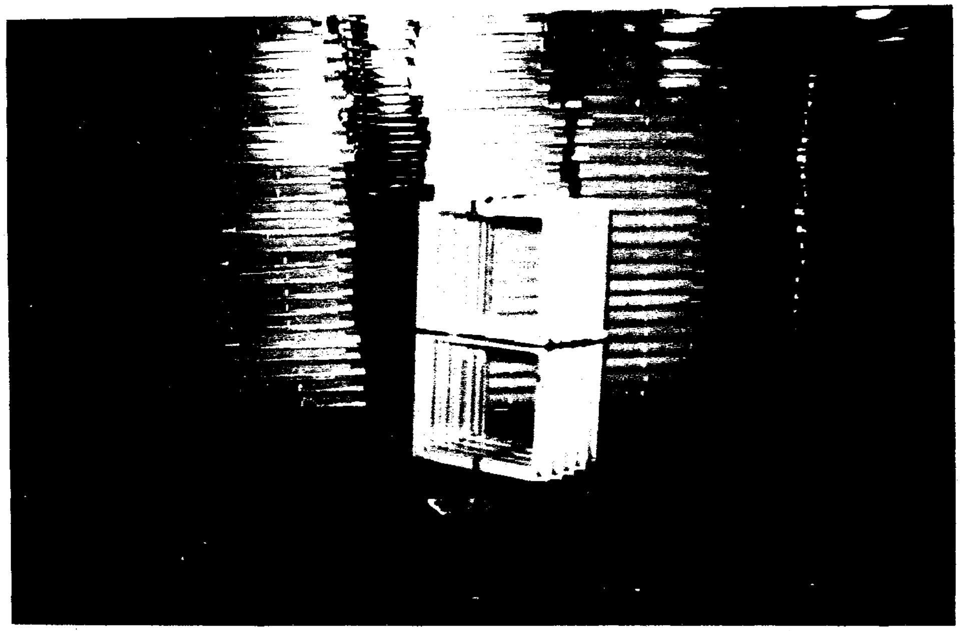

Figure 6. Present banded package of four window frames.

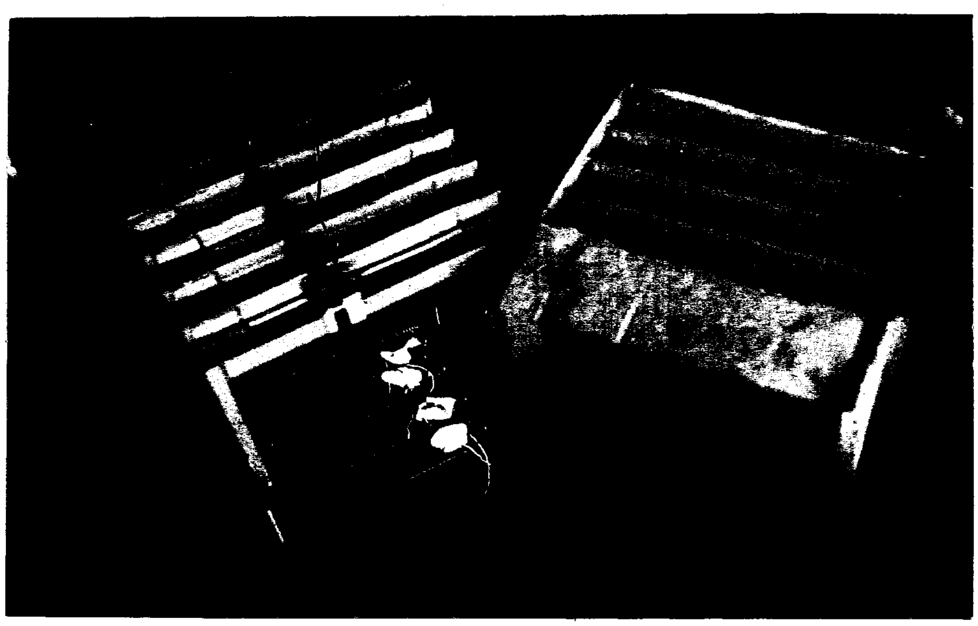

Figure 7. Detail of banding window frames and suggested new package.

improvement had been suggested of packaging the four frames in a kraft paper carton. See Figure 7. The estimated unit cost of these cartons was 35 cents for four window frames. At the time the problem was presented for discussion, no one in the group would hold out any hope of reducing the cost of packaging and shipping while using the cartons. The only hope expressed was that value could be increased without an appreciable increase in cost. Most of the group were even skeptical of the possibilities of doing that. However, the methods man started to accumulate actual material and labor costs of packaging under the present method. It was not long before he reported to the group that the costs which had been considered as almost negligible, were, in fact, higher than the cost of the new carton. In addition, although the complete costs were not yet available at the time the program was completed, a preliminary analysis of handling costs, after packaging, indicated that there were definite possibilities of substantial savings if the carton were adopted. At the time the program was completed, arrangements were being made to ship a sample carton of the window frames to Chicago and back, to test the effectiveness and durability of the carton. Here again, possible savings, not readily apparent, were found; and hidden costs in the present method were brought to management's attention for comparison and decision.

One model of wheel barrow was also used as a class problem for analysis. This particular model was called a Home Barrow, and was designed for the home gardener. Expected sales for this year totaled 5,000 units. Any improvements which might be made in this model could also be considered for other models also in production. Available cost data indicated that the present production plan was not economical.

A sample of the Home Barrow, packed for shipment, was brought into the session for analysis and improvement. See Figure 8. The group cut the steel banding holding the kraft paper cover, and unpacked and assembled it for examination. One defect was immediately apparent. While the kraft paper protected much of the exterior, the interior of the tray showed big scratches in the paint. One could only speculate on how much more it would have been scratched by the time it arrived at a hardware store for assembly and sale.

Each and every part was examined in turn, and its value-cost relationship appraised for all types of improvements. In this problem, it was interesting to note that suggestions for reducing the cost were made for practically every part in the assembly. Questioning revealed that the company currently had on hand many of the parts for this year's production; so it appeared that a more effective analysis could be made if it were planned for next year's production.

Figure 8. Home Barrow packed for shipment.

Accordingly, each and every part was again examined to see whether major changes in design would materially affect cost.

To cite one example, the wheel assembly contained two ball bearings. Everyone agreed that better value without an increase in cost would be possible if the ball bearings were replaced with a permanently lubricated bronze bearing. However, the sales department explained that sales appeal would be much greater for the ball bearing wheel than for an improved bronze bearing. They stated that hardware dealers would hesitate to stock wheel barrows which could not be advertised as equipped with ball bearings. Therefore, that idea was abandoned; but when the size and cost of the present ball bearings were checked, it was discovered that a small change in the bearing size to one more standard would make possible a very substantial savings in cost without impairing value. Since each person who would need to approve that change was present in the session, only a few moments were required to secure approval, and to start altered procurement procedures.

A check of the rubber tire size revealed that it was just larger than the minimum limit, and therefore subject to a 10 per cent government excise tax. Within the next week the purchasing agent had completed preliminary negotiations for a rubber tire which would be just under the minimum size, and therefore tax exempt, but would function just as well for the purpose. The ball bearings transmitted the load by means of a hollow shaft which had been finished on a centerless grinder. Operations to make it were expensive and added little to the value. The chief engineer suggested a method of cold upsetting mild steel rod, and then threading the ends of it. This would eliminate the hollow shaft and a bolt and nut assembly, and would cost little more than the bolt and nut which had held the assembly together.

In a like fashion the rest of the wheel barrow was examined for improvements. Not all of the ideas turned out to be useable. In some cases they depended upon the adoption of other ideas, and in some cases they were not feasible or were not economical compared with present methods and costs of production.

One interesting problem was attempted while the training program was in session. One of the members of the group mentioned that the packaging materials for the Home Barrow were almost exhausted, and that they should either be reordered, or changes agreed upon and the new materials ordered without delay. The entire group went to the packing department in the factory, and endeavored to improve the method and materials in order to lower costs. Due to the fact that so many of the handles had already been fabricated, this presented a difficult problem. No one was satisfied with the present method, and yet repeated trials to make changes without changing the handles were unsuccessful. The net result was that all agreed to leave the method and materials alone pending design changes in the wheel barrow for next year. The project was written up, the recommendation made; all signed it, closing it off within a period of two hours.

This example was cited and described in order to emphasize one point. This training program was not designed to be, and no claim was made that it would be a panacea for all the production problems which confront personnel in a company. It assisted in initiating group action; and in an orderly and systematic fashion, assisted in the definition of the problem, the development of possible solutions to it, and the selection and recommendation of the most economical of the different alternatives. This was accomplished through the cooperation of personnel who would most often be concerned, and the result was their collective judgment as to the best solution for the company as a whole.

The training manual, which is presented in the next section, is intended to serve as a guide, and a nucleus upon which to build the training program.

V. RESULTS

The training manual which is presented herewith includes basic material considered to be essential to the success of a training program for this purpose. In different companies, many questions of a varied nature may well be expected. It is essential that the instructor have a good understanding of related topics, as well as of the text material. It is also highly desirable to have top management indicate its support of the cost reduction program by actively participating in the initial training session, and in subsequent periods if possible.

Because of the particular shop language used in industrial plants, and considering the background of personnel who would come into contact with the training program which follows, the language in this training manual on pages 54 to 88 has been designed to meet this shop usage. It includes trade terms colloquially used, and other wording as suggested by Mr. D. G. Stohlman[1] and others who have had extensive experience in conducting training programs in industrial plants.

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[1]Stohlman, D. G. Louisville, Kentucky. Comments on wording of training manual. [Private communication.] 1953.

SOME APPLICATIONS OF THE PRINCIPLES OF ENGINEERING VALUATION-INDUSTRIAL ENGINEERING TO COST REDUCTION IN INDUSTRY

PURPOSE

To secure company-wide cooperation in identifying and eliminating wasted costs from industrial products and processes.

JUSTIFICATION

Increasingly keen competition is forcing us all to constantly look for methods of improving our products and processes, in order that we may compete successfully for a fair share of the markets.

INTRODUCTION

Each division in a company is charged with the responsibility of accomplishing its objectives in the most economical way. As new products or models are brought into the production plan of the company, they often require many changes. Attention is immediately directed to the cost aspects of these changes in order to assure that the new addition will contribute as much net revenue to the company as possible. At this stage of planning, ideas will be welcomed, and everyone will cooperate in completing the planning. Soon, a satisfactory and economical method of production will have been worked out, and the job of organizing it into a definite procedure will begin.

As soon as production gets under-way, there is probably just as strong a tendency to oppose any more changes. When an additional change is proposed, we often hear someone say "let it alone, it's making money for the company". It seems natural for production men to hesitate to disturb any part of the production which is a "going concern", and contributing revenue to the company. When the suggestion might involve several divisions of the company, this is especially true; because any change would require coordinated action from each of the divisions concerned. Also, sometimes a combination of ideas is needed in order to make any of them work satisfactorily.

Costs may rise in some departments, and we must be able to show how we can save that extra cost in addition to the cost of installing the new improvement. Even when that is possible, people in the departments where costs would increase are naturally hesitant about approving changes which will improve other department's cost statements, partially at their department's expense. In addition, we know, or should know, our costs for the present method; but we can only guess or estimate the cost effect of each change.

The result which often happens is that the improvements are pigeon-holed, and production is maintained without change until it is found to be no longer profitable. Then a decision must be made to either stop production, or to change the product or process; so a study is hurriedly made, the results summarized, and decision reached.

Meanwhile both good and bad ideas have been ignored for such a long time that most of them are lost, and the people who thought of them are discouraged from thinking of others. One often hears someone say, "I thought of that improvement two years ago, and told the boss, but nothing came of it. . . Now they are finally getting around to adopt it." Perhaps it is the same idea; perhaps not. What is important is that the workman thinks so.

What is proposed in the following training program is a means of checking and acting on these ideas, and more important, directing attention toward problems where ideas will have the most value, without waiting for a business crisis. The development of this program is not intended in any way to belittle the efforts or the results of work of existing groups or individuals in the company (such as methods units), which are charged with cost reduction responsibilities. Instead, the work outlined here should help to make their efforts more effective.

Representatives of each main division in the company are included in this group for the following reason. A problem which appears at first glance to be exclusively one of methods will, in many instances, have a solution which is found only through cooperation with some or all of the other departments. Any change which is made will seldom involve just one department or division of the company. In addition, each member of the group will secure a better understanding of the relationship of his department's work to the others as he works with the group in solving problems.

SCOPE OF STUDY

The program which follows has practical application to Production Planning in both design and methods, to production control, and to purchasing procedure, especially in smaller companies.

Certain problems must be considered as outside the scope of investigation. They include: any study designed to make workers work harder; questions involving financial policies of the company; selling methods; organizational changes in the company; methods of wage payment; and problems of similar nature.

VALUE VERSUS COST

Everyone knows what cost is -- the amount paid for some item. Suppose the item is not purchased, but is manufactured by the company. Then cost becomes more of a problem. The total cost of material used and the direct labor expended in making the units are both parts of the cost of production. In addition, so is a fair share of the other expenses of the business, the indirect and overhead costs.

Each time some money is spent on a unit, there is an addition to the cost of it. But each time money is spent, there may or may not be anything added to the value of the unit. Value has been described in many ways, but one which has stood the test of time is that value is the worth of something, the exchange worth. Accordingly, an item might cost five dollars or fifteen dollars, and yet in either case it might be worth ten dollars. Cost has little relation to value other than that often expressed in industry, "when it costs more than it is worth, we cannot afford to make it".

Years ago when copper and brass were less expensive, many items were designed, using one or the other of them for materials. No doubt that was the most economical way to produce the item at that date. As time passed, the relative cost of these materials increased in comparison with other and equally useable ones. There were complaints about the increased cost, but in many cases nothing was done until the shortage of both copper and brass during the war forced govermmental regulation of their use. Various companies then found out that their competitive position would have improved earlier if they had been forced to make the change years before. That is, while they made money on their product, they could have furnished a product of equal value, but costing less, with a change to other materials.

Machine speeds and feeds of past years were determined generally by the tools and materials available at those times. More recently, newer tools have been developed which permit much faster and more accurate machining, yet result in longer tool life. With these improvements, it would appear that methods changes in processing would also have taken place. However, we find many of the new tools being used without any increase in the speed of machining. When we ask, we are told that the power capacity of the machine is not adequate to utilize the tool to its maximum, and besides, we are already effecting a saving due to the longer life of the tool when it is run at the reduced speed!

The question really is: Are we or are we not operating in the most economical fashion? In order to answer that, we must be able to answer questions of design, methods, materials, tools and equipment, and of costs, whether parts or product are purchased or produced. And we must furnish facts and figures which will stand up under the most critical scrutiny. We must be sure that value is adequate, and that costs are at a minimum. Each of you has been accustomed to solving certain of the problems which arise, so as a group, you have been selected to train and work together, coordinating the information your departments may have, and your special skills, to achieve the greatest economy in production for the company as a whole.

ANALYSIS PROCEDURE

The steps listed below briefly outline our analysis procedure.

I. Classify products, parts, and other items into groups according to the total planned labor and material cost in them. This serves as a guide toward those which offer the best chances for improvement in cost. Select one item for investigation.

II. Get facts about the item selected.

   a. Quantities produced in the past, and planned future production (time and quantities).
   b. Plant productive capacity for the item.
   c. Present method used to produce it.
   d. Materials used.
   e. Equipment and tools used.
   f. Production space and storage space requirements.

III. Determine and tabulate those elements of cost to produce the item that are available. Estimate those elements not determinable. Separate the different elements of cost in a form which will facilitate comparison for economy studies.

IV. Examine the item carefully; ask yourselves and each other all of the following questions[1] which have application to the problem. The answers to the questions will be the guide to economy that we are looking for.

1. What function does it perform?
   Does its use contribute to value?

2. Is its cost proportionate to its usefulness?

3. Are all of its features necessary?
   Can any part of it be eliminated--or combined with another part to facilitate manufacture?

4. Is there anything better for the intended use?

5. Can a standard item be found which is usable?

6. Can a usable part be made by a lower cost method?
   What other materials could be used? their costs?

7. Are present machines being operated at the most economical speed? feed?
   Is it made on the proper tooling, considering volume?
   What jigs or fixtures would facilitate manufacture? Cost?

8. Can the desired finish be produced by other means? less costly?
   Are design tolerances too close for the accuracy needed?
   Will any changes in design simplify fabrication without impairing its value?

9. Is the flow of production balanced to best utilize machines and men?
   Do materials, reasonable labor, reasonable overhead and reasonable profit total its costs?

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[1]Included in the questions are the "Ten Tests for Value" developed by the General Electric Company. Original not available for examination. Reprint from June, 1950 Purchase for Profit issue, Purchasing Magazine, 205 East 42nd Street, New York 17, N. Y.

10. What other machines could be used to produce it? Could any of them be used to advantage? currently available?

11. Can another dependable supplier provide it for less? Can anyone buy it for less?

12. What can be done to reduce cost of handling? packing? shipping? record keeping?

SELECTION OF A PROBLEM

The following paragraphs are intended as a guide to help direct our attention toward the better cost reduction possibilities. It seems reasonable to expect that items which require a larger annual expenditure also offer better possibilities for realizing a net saving, when analyzed for possible cost reduction. This would always be true if each operation, part, or product offered equal chances for improvement. However, some changes may affect several departments, requiring consideration by more people, and a higher degree of executive approval. When this happens, costs of analysis are greater, and savings must also be greater if we are to succeed in our purpose. For the above reasons, the accompanying graph has been prepared to help us direct our attention toward problems which should present the best chances for net savings. See Figure 9.

On the graph, each of the curves join points of equal (combined material and labor) costs. We will assume that the average cost of an analysis is $400. For instance, we examine a part for possible improvements and we feel that we ought to be able to reduce the cost of making it. Planned future production is 20,000 units. The direct material and

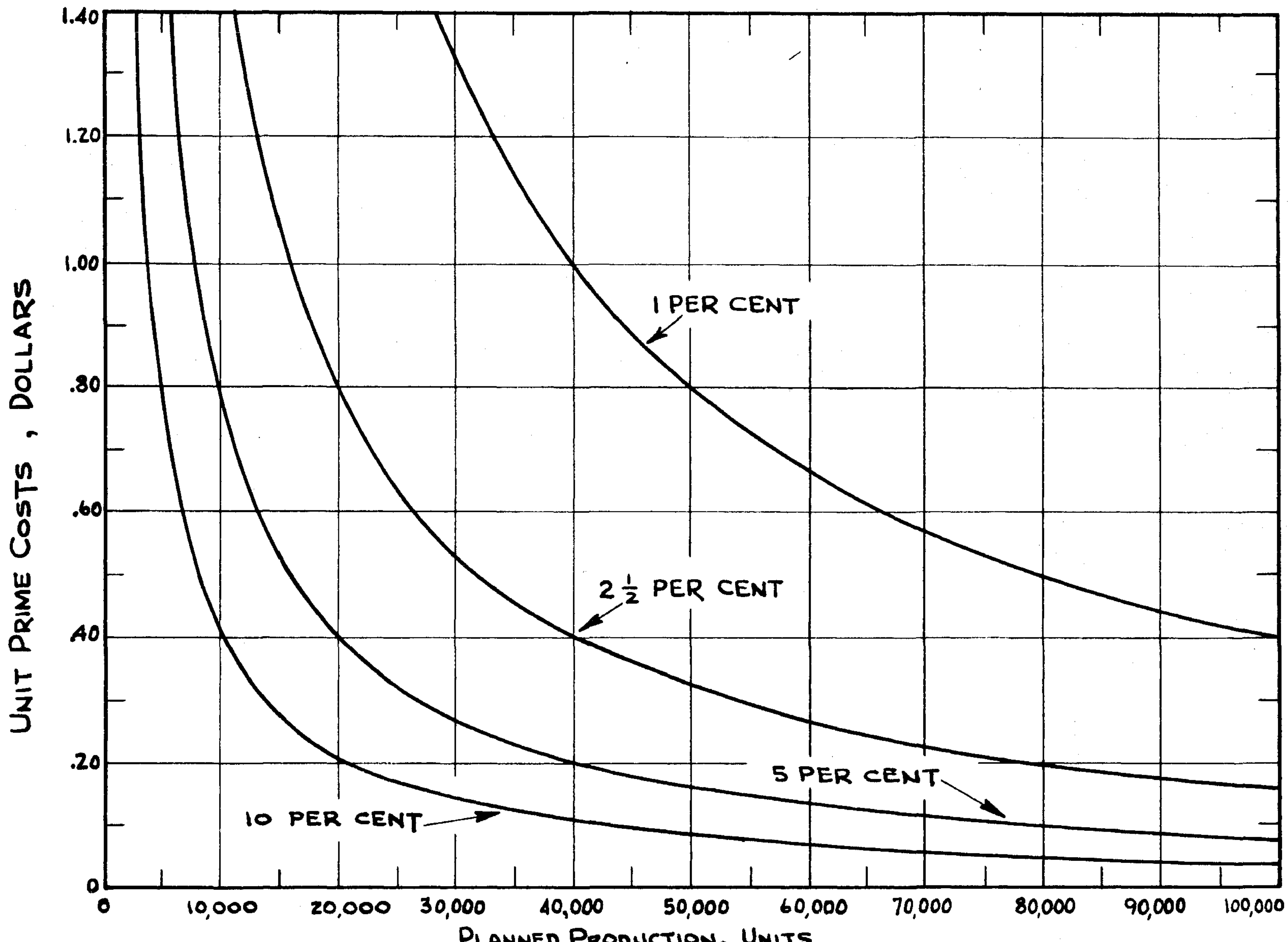

FIG. 9. — ANALYSIS POSSIBILITIES AND SCORE SHEET.

labor costs (prime costs) average 20 cents per unit. We plot the 20 cents and 20,000 units on the graph and find that we are on the $4,000.00 cost curve. If the cost of securing that expected saving is $400.00, we must expect savings greater than 10% or we will not accomplish what we set out to do. Plotting possible studies on the graph should simplify the selection of those studies which seem to offer the best chances for cost reduction.

COMPARING COSTS

PRESENT WORTH METHOD

Whenever we wish to make comparisons between two or more alternative ways of doing work, we must be certain to make the comparisons equitable in every way. To illustrate, assume that we have estimated the annual savings of some method "A" to be $0, $0, $500, and $500 respectively for the next four years. By using method "B" the savings are estimated to be $250.00 each year for 4 years. Which of the two methods is preferable? and how many dollars better? The method we use to find the answer is to compare the value of both sums of money at some one time, usually the value now, called present value. Let's assume money costs 6% if we borrow it, and that the company's rate of return is the same. The present worth of the two methods is as follows:

Method A

$500 to be received at the end of three years is	$419.80
$500 to be received at the end of four years is	396.05
Total	$815.85

Method B

$250 to be received at the end of one year is	$235.85
$250 to be received at the end of two years is	222.50
$250 to be received at the end of three years is	209.90
$250 to be received at the end of four years is	198.03
Total	$866.28

The difference, $50.43 represents the amount of extra interest discount if method "A" were chosen. Whether or not we have to borrow the money from the bank, interest charges should be included in costs, because money could be earning a return somewhere else if we did not tie it up in this operation. If the interest rate were higher, the difference would be greater; if lower, the difference would be less. If money did not have any interest cost, both methods would return the same amount, $1,000.00.

ANNUAL COST METHOD

Another method of cost comparison is often used for work such as we are engaging upon. It is called the Annual Cost Comparison Method, and is especially useful where equipment of both methods is expected to last the same length of time, or where replacement of the shorter-lived equipment can be made at the same price the first units cost. If we can gather together all of the costs, and express them in terms of an equivalent annual charge which will just equal the total expense, then we will be able to compare alternatives, determining how much more or less the annual cost of any one method will be when compared with any other.

To illustrate, perhaps we wish to compare the costs of two ways of doing an operation. One method, "A", would use portable power tools, which would last an estimated ten years, and cost $1,000. Daily productive capacity would be 200 units each 8-hour day for each production center. The other method "B" requires use of a machine costing $20,000, which will be used for an estimated two years. Using this machine, productive capacity would be 1,000 units per day. Our planned production is 2,000 units per day. We would need ten production centers using method "A", or two centers using method "B". Let's assume labor cost at $1.50 per hour for both jobs, and 2,000 hours (50 weeks at 40 hours) per year of production. To simplify calculation, let's assume that the other charges - material, power, maintenance, space rent and all over head charges will be the same for either method, and amount to $30,000 per year. The annual depreciation costs for the two methods would be as follows:

$$\text{Annual depreciation cost} = \frac{\text{Total depreciable cost}}{\text{number of years in use}}$$

The total depreciable cost is the cost new (installed) less net receipts from salvage or scrapping the unit at the end of production. Let's assume that scrap value equals cost of removal and disposal. Then our depreciable cost is the total cost new for each of the alternatives.

$$\text{Annual depreciation cost method "A"} = \frac{\text{(10 units) (\$1,000 each)}}{\text{10 years}}$$

$$= \$1,000 \text{ per year}$$

$$\text{Annual depreciation cost method "B"} = \frac{(2 \text{ units})(\$20{,}000 \text{ each})}{2 \text{ years}}$$

$$= \$20{,}000 \text{ per year.}$$

We also need to determine the cost of keeping money invested in these machines, the interest cost. It is the amount which could be earned if the average capital cost were invested elsewhere. Let's assume 6% as a fair return. One way to figure the average investment is to add the cost when new of the equipment and its worth (net value) when it is sold or scrapped; then divide the total by two.

Average investment, method "A" =

$$\frac{(10 \text{ units})(\$1{,}000/\text{unit} + \$0/\text{unit})}{2}$$

$$= \$5{,}000.$$

Average investment, method "B" =

$$\frac{(2 \text{ units})(\$20{,}000/\text{unit} + \$0/\text{unit})}{2}$$

$$= \$20{,}000.$$

The Annual interest charges for the two methods are as follows:

$$\text{Annual interest charge, method "A"} = (6\%)(\$5{,}000)$$

$$= \$300.$$

$$\text{Annual interest charge, method "B"} = (6\%)(\$20{,}000)$$

$$= \$1{,}200.$$

The annual labor costs for the two methods are as follows:

Annual labor cost, method "A" = (no. workers)(hours/year)(rate per hour)

= (10)(2,000)($1.50)

= $30,000.

Annual labor cost, method "B" = (2)(2,000)($1.50)

= $6,000.

A comparison of the total annual costs of the two methods is as follows:

Item	Method "A"	Method "B"
Depreciation	$ 1,000.	$20,000.
Interest on investment	300.	1,200.
Labor	30,000.	6,000.
Material, Maintenance, Power, Space Charges, Overhead	30,000.	30,000
	$61,300.	$57,200.

As the comparison now stands, there is a $4,100. annual advantage to be gained by using method "B". This advantage would hold true for the period of our planning, assuming no change in costs as set forth. However, one can seldom predict the market demand for an item two years, to say nothing of ten years, in advance. Availability of capital, alternative uses of the machinery, and market and employment trends are all factors which would be given proper consideration, before a decision is reached. For our purposes, it is desirable to think only in terms of the planned production period, after which any special equipment which might have been acquired, should be salvaged. In the above case, if the planning is for one year, either $9,000. of the equipment of method "A", or $20,000 of the equipment of Method "B" would need to be salvaged. The $4,100 advantage shown by using method "B" is dependent upon how well we would be able to realize the full amount of salvage.

DEPRECIATION

From the illustration of annual cost determination we can see that when we measure the depreciation of a machine or other piece of equipment, we do not necessarily mean that we will wear the equipment out in use before we dispose of it. If its purchase and use for a shorter period of time are indicated as the most economical procedure, then unless its use on other production is indicated by a later study, we must plan to dispose of it when our planned production is concluded if we are to realize the savings we planned.

What do we depreciate? Custom applies the term to equipment and durable tools which are used to make the product but do not become a part of it. The word is also applied to factory buildings and other durable possessions. Common causes of depreciation include:

1. Physical Causes - wear and tear in use, deterioration with the passage of time, and damage from accidents or catastrophe.
2. (a) Changes in the style of equipment. (b) Development of new units which accomplish the same purpose

at less cost.

3. Causes from outside the company. (a) By government rule or regulation. (b) Bankruptcy or failure in the business. (c) Reduced demand for the product.

4. Decision of Management.

In these studies we are concerned directly with the wear and tear effect, and less directly with the others, limiting them to an estimation of their effect upon the salvage value of the equipment at the end of our planned use.

Therefore, the total amount of depreciation to us is the in-place cost of equipment, minus net receipts from disposing of it at the end of its period of usefulness. Please note that we are referring to depreciation in terms of the cost to secure and install equipment; and its net salvage or exchange worth when we dispose of it. Our aim is to determine and estimate all costs as accurately as possible so that we may pick the most economical alternative. Therefore, we estimate the total amount of depreciation which will take place and then divide it by the time it is in use, or by the total production, in computing a depreciation rate.

The Internal Revenue Department has set-up schedules which show its estimate of the average life for each of many different types of equipment, and the corresponding depreciation rates which they will accept for use in depreciation calculations. Our depreciation rate for a cost-reduction study may or may not correspond to this figure. Remember, we are considering a particular piece of equipment - which probably does not correspond to the average they speak of.

BOOK VALUE - CAPITAL GAINS - SUNK COSTS

Let's look at another problem we will probably face. Assume that we now have one surface grinder which cost $1,000 ten years ago. It works perfectly, and we plan to use it for future production. However, two machines will be needed, so we start to find a second one. We discover that the cost of a new grinder (installed) is now $3,000 and that it has an expected life of 20 years, the same as the old one. We shop around, and find that we can get used machines of like age and condition as our present one, but that they cost $1,200. Our present grinder is now carried on the books at $500 (book value). Everyone says that it is a pity we didn't buy two grinders ten years ago, and save the $700. Besides, we wonder if the higher costs using either the $1,200 machine or the new one would cut savings below the level of economical production. What should we do?

Our choice should be made in the way that will help the company most of all. The economy we look for is economy of production. What would we do if the original cost of the first grinder had been $3,000, present book value $2,000, and used ones like it available on the market for $1,000? You can be certain we wouldn't want to carry the extra "cost" of the first purchase into our study. We would be apt to say that the company could do anything they want to with that first grinder; we want to buy two grinders at $1,000 each, and make some money with them. However, whether its book value is more or less than cost on the market today, one grinder is already bolted to the floor in the factory, and needs to be used.

We can still handle the situation if we understand what book value represents. It is the present undepreciated cost of the grinder, carried on the books in that way for tax purposes. If we were to sell the grinder for $1,200, the $700 over book value (less cost of removal) would become a capital gain. If we sold it for $1,000 and the book value were $2,000, the $1,000 difference would be a sunk cost, and could become a capital loss credit for tax purposes, provided it was claimed when the loss was legally allowable.

Either of these situations may occur, especially when prices are changing in any amount. Oftentimes, a machine is purchased, in good faith, as the most economical one available at that time. A short time later, an improved machine appears on the market and makes the first one obsolete (in the same way that jet engines suddenly made propeller type engines obsolete in combat aircraft). It wouldn't be fair to "saddle" our economy study with the extra costs of obsolescence, and it wouldn't be fair to claim savings resulting from past purchases which turned out better than anyone expected. They are both matters for financial policy determination outside the scope of our study.

The result is that we should not use the book value of existing equipment for our studies - we use its "fair exchange worth". If any equipment is "under-valued" on its books, the company will then get the benefit of that extra value, as well as the savings shown by the valuation-economy study, just as if the old machine were sold and the "new" one purchased and installed. Added to that saving is the expense of removing the old machine and installing the new one, both of which are avoided. If the machine is over-valued on the books, it may be necessary to dispose of it in order to claim the capital loss. This is a question which depends upon the depreciation method used by the company, and Internal Revenue Bureau policies relating to that form of loss. The question can best be answered when the situation actually occurs, and its determination is not necessary for our work. To be on the safe side, our best method is to calculate costs as if all of the equipment used must be purchased now, and to use current market price plus installation charges for our base cost, deducting only the amount we expect to net from salvaging or scrapping the equipment when its use is over.

The difference between those two figures becomes the total depreciable cost we need for use in our studies.

BREAK-EVEN POINT CALCULATIONS

When planned production may vary considerably, it is desirable to have a continuous record of cost at all production levels. When we wish to compare the costs of two or more methods of production, plotting both sets of costs on a single graph facilitates comparison. It is also possible to plot net receipts from sales on the same graph, and to compare revenue with production costs, estimating the net profit or loss which might result at any given level of production.

Our costs are divided into two classifications. Fixed costs are those which will occur whether or not any goods are produced. Variable costs are those which vary directly with the amount of goods produced.

To illustrate, let's assume a part - a gear. Our total annual production is uncertain, but may reach 60,000 units per year. We can make the gear by cutting it on a hobbing machine; or we can use plastics, and mold it. If the selling price is 32 cents per unit, at what production will the profit be greatest? At what production will costs be the same regardless of the method used? At what productive level will receipts just equal expenses? Assumed costs are used in the example which follows to simplify the calculations.

Item	Metal	Plastic
Fixed Cost (per year, per machine)	$3,000.00	$7,500.00
Variable Cost (per unit produced)	0.10	0.02
Capacity per machine (annual)	15,000 units	50,000 units
At 60,000 units production the number of machines required	4	2

The break-even points between receipts from sales and cost of manufacture of the metal gears occur at points 1, 4, 5, and 7, on Figure 10. Note the increasing area of possible profit following each successive break-even point. The break-even points between receipts and costs, using plastic molding occur at points 2 and 6. At point 3 on the graph costs by the two processes are the same; but both costs are nearly $2,000 higher than receipts. Maximum profit would result from the capacity use of one plastic molding machine. At this production, profit would total $7,500. Increasing production above 50,000 units, and adding a second machine eliminates all of the profit until production again increases.

From the above analysis, we see that much useful information can be gained by the development of these charts.

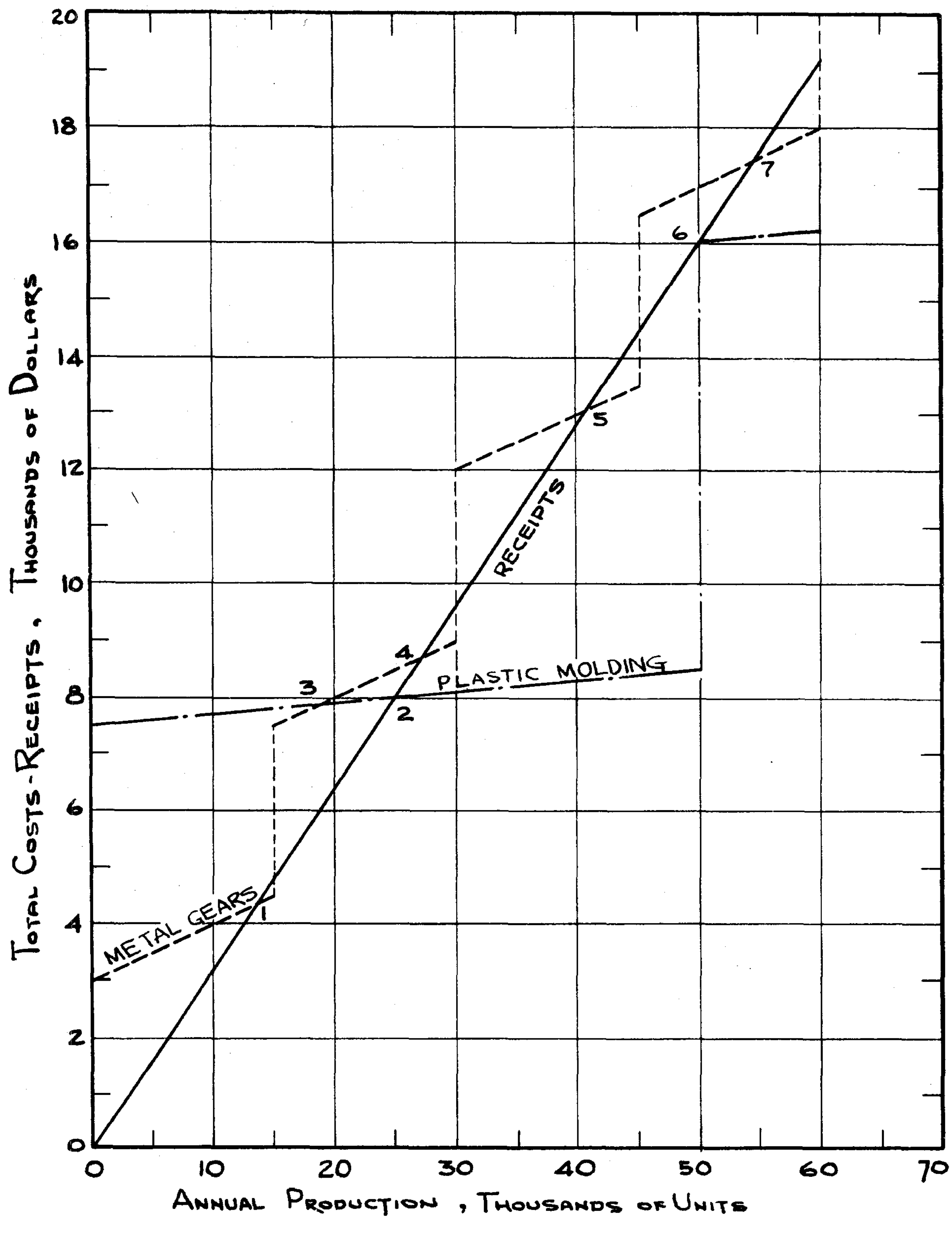

FIG. 10. COST COMPARISONS BREAK-EVEN POINTS QUANTITY ANALYSIS.

ESTIMATING AND DETERMINING COSTS

Most people feel that the job of accumulating costs belongs exclusively to the Accounting Department. It is probably true that first responsibility usually rests there; but it is also true that other departments must furnish the information necessary for cost accounting to properly identify costs. The form in which this information is furnished usually makes accounting's job easy or difficult, and the results more or less usable.

If we know what information is necessary, then it is easier for us to furnish much of it in its most usable form. This saves both the operating departments and the accounting department time and trouble. It reduces the cost of making these analyses, and makes them more effective.

Estimating has been described in many ways. We estimate whenever we do not know and cannot determine the exact answer to a problem. To some people, estimating means to "pull the answer out of a hat". To others, it becomes a more exact process. We are fortunate in this regard because our procedure for estimating costs starts out the same as it does when we determine costs.

Our first step is to gather all the available cost information that will help us. Next, we sort it into usable form, and see if any costs are lacking. For those costs still missing, we try to discover some other source which will yield the desired information. We wish to leave to judgment only those elements of cost we cannot determine, so we now gather all data that we need to help us make a reasonable estimate. Especially useful is any information which will help us to set "limits" on the figure we are seeking. To illustrate, suppose the cost we are seeking is $400 (although we do not know it). If we are able to determine that the figure we seek is not less than $350, or more than $450, we have improved our ability to complete the cost estimate. We arrive at these limits by listing all costs which we know are included in the estimate. This total then becomes the lower limit. Next, we list costs which we know are only partly chargeable to the cost of the item we are seeking. The total of these costs plus the previous total becomes our upper limit. Now we are in a position to exercise our judgment as to the degree or per cent by which each of this second group of costs should be included. Developed item by item, our cost estimate has now become one we can use with a good measure of confidence.

The general groupings of cost which will require some estimating may include those for both material and labor.

However, it is in the allocation of our indirect expenses - the overhead cost - that we will find greatest use for the estimating procedure outlined above.

COST REDUCTION REPORT

The cost reduction report is one form we may use to summarize the results of our work and secure action on them. Its purpose is to present all pertinent information in a way which will assist management in arriving at a sound decision. The report should include both the factors which favor the recommended alternative and any disadvantages or limitations. Its parts should include:

1. A comparison of the present and recommended methods.
2. A comparison of the operating costs of both methods.
3. An analysis of investment requirements involved in the change.
4. An estimation of the expected savings.
5. A description of the specific action required in order to accomplish the proposed changes.
6. The proposed time schedule to make the changes.
7. Spaces for recording the approval of those in authority.

Some companies have adopted forms for initiating and approving cost reduction projects. When that is true, it is suggested that an attempt be made to adapt any existing form, making certain that it includes each of the above items. For companies which are currently without a form, an adaptation of the sample form on the following page is suggested. See Figure 11.

COST-REDUCTION REPORT

Description of item involved. Date

Dept.

Operation

Object of Analysis

COMPARISON

Present Method	Proposed Method
Machine	Machine
Tools	Tools
Description	Description

Cost of operations involved	Cost of operations involved
Labor	Labor
Materials	Materials
Misc.	Misc.
Total of above items	Total of above items

Estimate of Saving

Saving with proposed change $\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_$

Probable yearly requirements__________________

Estimated savings per year (based on)__________________

Estimated cost of change | Changes required

Design $

Equipment $

Installation $

Total cost of change $

Signature | Approved | Disapproved

Figure 11. Suggested Cost-Reduction Report

VI. DISCUSSION

Evaluation of a program such as that developed in the preceding sections might best be made on the basis of the dollars and cents saved in production following completion of the training. It might also be made by observing the character of the improvements discovered, and by analyzing them in terms of the principles and practices included in the training program. An additional indication of the value of the training might also be gained by observing the feelings of those who were included in the program.

Analysis of the change in packaging of steel window frames has just been completed. The analysis itself cost nearly $200, and it is estimated that an additional $100 will be expended for installation of the change. The estimated savings by the use of the recommended method is $2.46 per thousand windows. Annual production for the past few years has averaged 300,000 units. On the basis of that estimate, for the coming year savings will total $738.00 for an investment of $300.00. There is no reason to suppose that production will change in the near future. The product is a standard basement window, which should be in demand in direct proportion to the amount of home construction undertaken, where the design includes a basement.

In this study, material cost for the carton was appreciably higher than the direct material cost of the banded product. In fact, the increase was so pronounced that the purchasing agent was very pessimistic about recommending that item for study. However, he readily cooperated in carrying the study forward after the group had agreed to try it. The design of the cartons, including dimensional and strength specifications, was of immediate interest to the design engineer and the methods engineer. It was readily apparent that labor time for assembly into the carton would be less than that required for banding window frames together, so the methods engineer was inclined to be enthusiastic. Since weight of the windows was one controlling factor in limiting the number which might be packed together, the company's part in design of the carton was rather simple. Prospective carton suppliers handled the strength specifications to insure that the carton would conform with shipping regulations.

The other controlling factor in carton design required the design engineer to contact the sales department and make sure that cartons, which would hold the same number of windows as were being banded together, would be satisfactory for the customer. The idea was received with enthusiasm, and approval granted on that basis.

The production representative was concerned from a number of standpoints. First of all, change in the method would also change the balancing of the production lines. After the method analysis was completed, it was discovered that the result would be an improved balance. In addition, extra handling would be eliminated, since the window frames could be packed in cartons as they were taken off of the paint drying conveyor. The old method had involved stacking and moving them to storage before banding them together. The cartons could be moved to storage without further handling; and also movement from storage to the loading dock and either into truck trailer or railroad car could be accomplished by mechanical means for the packaged carton. The new method would also result in much faster loading of trailer or railroad car, and increase the capacity of the loading dock.

The main problem in assembling accurate costs occurred in determining present labor costs, and estimating cost aspects of changes in the proposed method. It was in this part of the analysis that many of the "hidden" costs in the banding method were discovered and measured. To illustrate, please refer to Figure 7. Tension from the banding steel would bend the metal flange of the windows at both ends of the bundle. To protect the flange, a small wooden block has been placed between the two end flanges under each band. See arrows on Figure 7. Tolerance on the size of the blocks was so close that the operator who cut them was able to make only 658 per hour.

The operation of positioning the blocks and holding them in place until the band was tightened also contributed to the present high labor cost.

It was agreed by all of the group that if cost by the new method could come close to matching cost by banding, the change would be worth-while. Not only was that objective accomplished, but an actual cash saving was shown to result. Would this improvement have been accomplished without the training program? It might have been possible, but its probability would be very questionable. No one in the group held out any hope of savings when the probable cost of the carton was first announced. However, the group agreed to carry out the analysis as one test of the effectiveness of the program. All costs were very carefully measured or estimated. The result was a recommendation to management which showed definite promise of reduced cost. The methods engineer was especially enthusiastic about the cooperation everyone showed in making the analysis. The recommendation of the group, contained in the report of the study, showing both cost and savings, has greatly improved chances for its acceptance by top management.

An application of the program to cost-value analysis of paper work was suggested during the last training session. At the beginning of the period, the cost accountant mentioned his lack of success in eliminating a certain efficiency report required by management at that time. It represented an expenditure of more than 38 man-hours of work every week, and currently was being completed about four weeks later than the work being measured. He had attempted to secure its elimination, but had been told to continue to prepare it.

The group set down the essential facts sbout it on a cost reduction report form, but suggested a short delay in action, because strong personal feelings had been evidenced during the discussion. Sometime later, the project was re-opened, and approval secured to substitute information which would be equally adequate, but more easily secured. This one change, requiring about five hours of analysis, resulted in a saving of 38 hours per week, or more than $200 per month. In addition, the information is now being compiled within 24 hours of the production, instead of the four week delay which had previously existed. Members of the group expressed the opinion that this improvement would not have resulted if left to individual action.

No data were available concerning improvement in the Christmas tree holder. It was stated that re-design, in line with the recommendations of the group, was progressing; but had not been completed. At the time of the training program, estimated production for this year had been 300,000 units. Two months later, orders on hand totaled 750,000 units. This would seem to indicate that any savings which may result from ideas developed by the group will have even greater value next year.

While a complete re-design of the home barrow has been delayed until next year, certain improvements were possible in this year's model. The wheel mounting assembly was one of these. See Figure 12 for an exploded view of the old and improved parts. In the old method, the assembly was made up of a bolt, a hollow sleeve with a centerless-ground outer surface, and a lock washer and nut. The improved assembly consisted of a piece of hot-rolled steel rod, which has been "necked down" at each end and threaded for a lock-washer and nut.

The new assembly contained one additional part. It was also probable that the assembly time has been increased slightly. Would this change have taken place without the impetus of the training program? At the time the assembly was inspected and its value-cost aspects assessed, several members of the group expressed the opinion that the ball-bearing wheel required the use of a sleeve such as the old assembly included. Only one member of the group was able to suggest a possible change, that being the cold upsetting of a rod to furnish the bearing surfaces for the bearings. Later

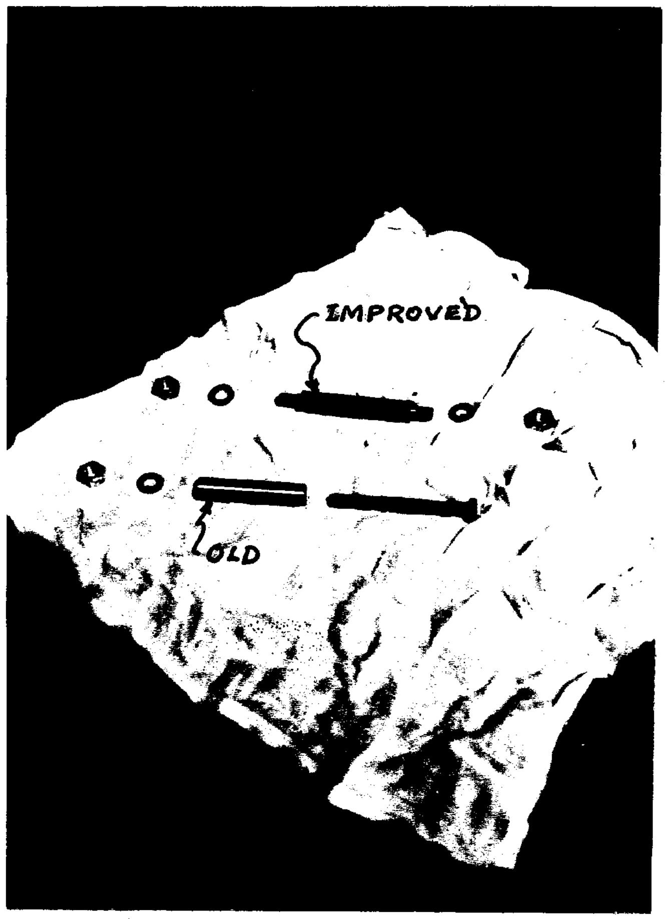

Figure 12. Wheel mounting assembly.

investigation disclosed difficulties in obtaining such a part this year. However, the new part could easily be made on automatic screw machines, and was readily obtainable at a very reasonable cost in this area. That fact has led to its being adopted as a modification for current production, with a resultant saving, and without impairing value.

In other types of training programs, would a change such as this one be likely, or would training such as this program contained enhance the possibility of developing the improvement? The old part functioned perfectly well. There had been no complaints regarding its cost, which was not unreasonable for a hollow sleeve with a ground exterior surface. Methods men would not be apt to discover the improvement since the new method involves additional motions. Purchasing agents might be required to seek a substitute if ground parts were unavailable, but they would not be expected to have the technical know-how to realize that all of its features were not absolutely necessary. Design men would not be apt to know that the cost of the machine screw part would be less, and that it would be more readily available for purchase in this area.

One additional advantage of the new part was also evident. Round steel rod would be more readily available in other sizes too. If the bearing size is changed in next year's model, any standard size rod will be readily adaptable, where procurement of the hollow sleeve in other sizes might present additional difficulties and added cost.

It would appear reasonable to assume that, in view of the above analysis, chances for an improvement such as this one would be greatly enhanced when analysis was done by the group included in the training program. Their attention was specifically directed to questions of value, as well as of cost. And the technical questions involving the several departments were more readily settled within the group. Also they all shared credit for each of the improvements which resulted.

Another improvement which has been developed and included in the assembly was in the wheel itself. The attempt to re-design the wheel, described earlier, has not yet been completed. However, a different wheel has been procured which has resulted in a substantial saving in cost, although the excise tax has not been eliminated.

The combined effect of the improvements adopted to date has resulted in a decrease in cost amounting to more than $0.33 for each unit. Production for the year had been estimated at 5,000 units. During the two month interval since the training, the estimate has been constantly revised upward. Shipments during the third week in April totaled 3,000 units, and at that time there were orders on hand for more than 3,500 more of the home barrows. The old stock of parts had been used up prior to that time. On the one week's shipment mentioned above, savings totaled approximately $1,000. Prospects are good for an increasing amount to be saved in future shipments.

A description was given earlier in the thesis about an attempt to improve the packaging of the home barrow. At that time no improvements were discovered, and decision was made to delay action until later. Subsequent to completion of the training program, the group met and reconsidered the problem in connection with an additional factor. The problem proposed was to increase capacity of the semi-trailers used by the company to distribute the wheel barrows to dealers throughout the U.S.A.

The carton idea was again suggested, and approval was gained to permit packing more than one unit in a carton. Details of the new packaging are shown in Figure 13. The three trays were stacked together, nesting compactly in. A piece of cardboard was placed in the top tray, and the accessory parts placed on it. This eliminated the scratching of paint, discussed earlier. The three sets of handles were placed on top, the covers closed, and the entire unit banded together. See Figure 14. The top unit in the picture was of a single home barrow in a carton. The others, under it on the pallet, were box-type cartons, each containing three barrows.

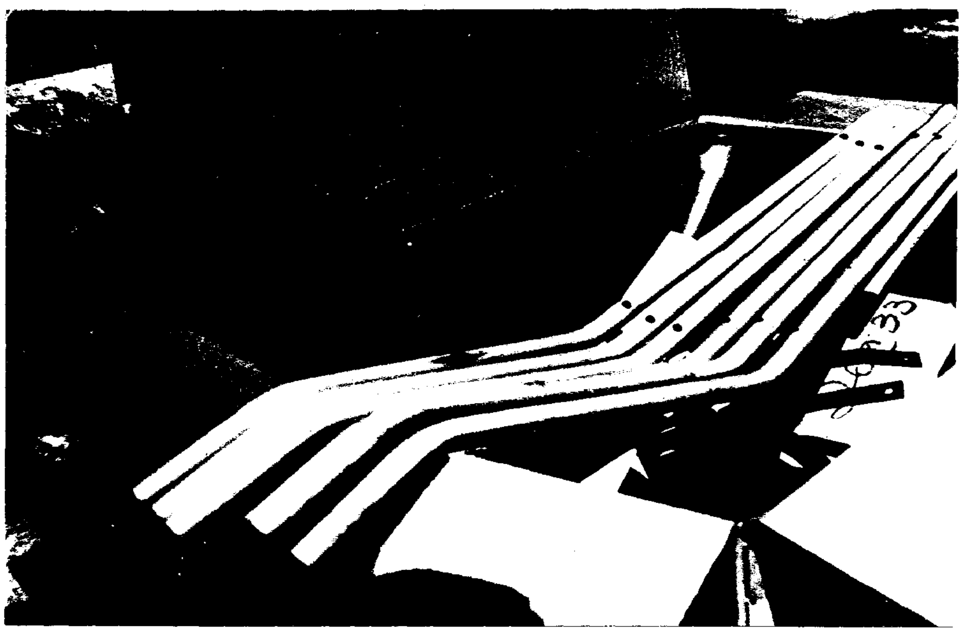

Figure 13. Detail of improved multi-unit package.

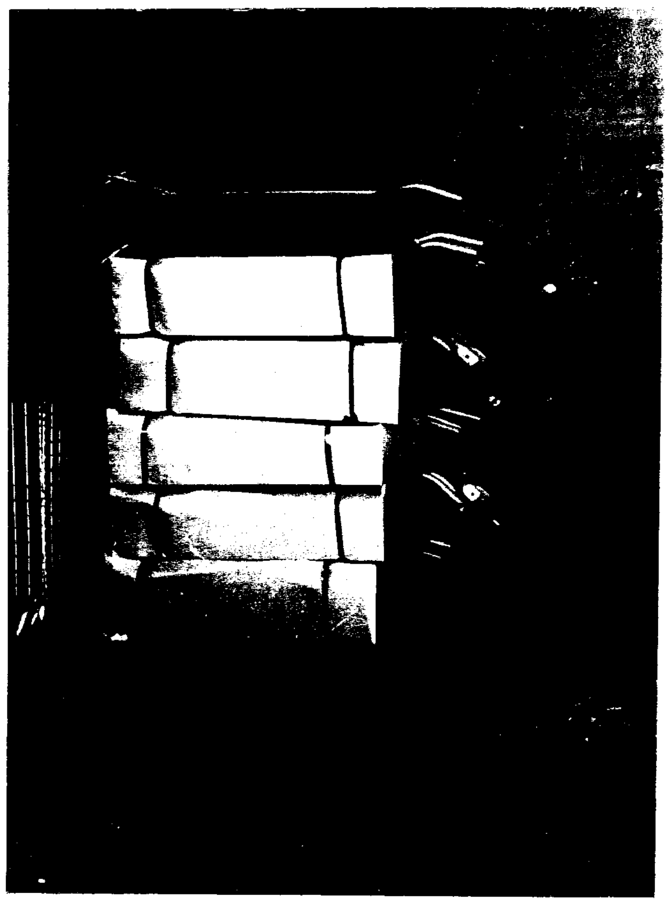

Figure 14. Single and multi-unit packages.

Single unit packaging is now used only to complete orders for wheel barrows which are not in multiples of three. Limitation on the number which may be packaged together is now the weight of the completed package. These packages are easily loaded into a semi-trailer, and result in a load capacity three times as great as before. See Figure 15. When it is realized that shipments are being sent to the East and West Coasts, and to the Gulf of Mexico, the importance of this saving in cost becomes evident.

Would this improvement have been possible without the benefit of the training program? Probably yes. However, all who took part in the program agreed that they were able to approach this problem and find a satisfactory solution much faster, after the training. Each of the different departments was directly concerned in the change, and it is likely that the value-cost approach was useful to them in preparing and presenting their recommendations to management.

In response to a direct question from one of the participants in the training program, the following analysis was presented to the group. The question asked was "how cost and revenue could be related in order to determine the most economic production". It developed that the questioner meant the maximizing of profit to the company was intended when he described it as the most economic production.

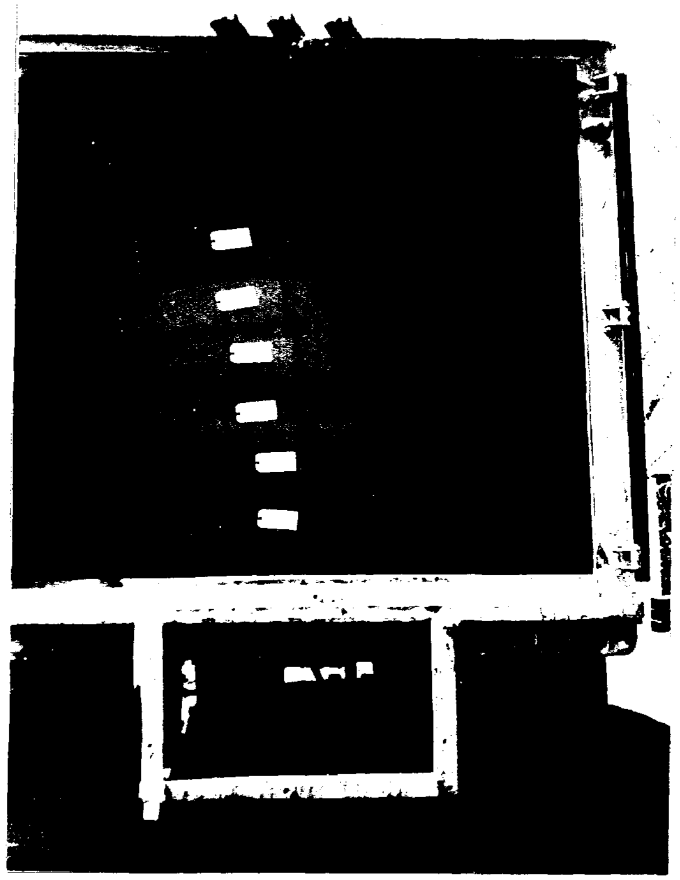

Figure 15. Loading packages into semi-trailer.

These men were all production men. However, they knew that when they had to ask their men to work extra hours at over-time rates in order to meet production schedules, much of the company's profit was lost in the higher labor cost schedules. Then later the same men would be called "on the carpet" to explain those higher costs. None of the men felt that there was anything they could do about it, but they were curious about the relationships.

At all times, they spoke of other companies as competitors who were able to affect their firm's business. However, they also defined production conditions as being fixed as soon as the initial planning was completed. The company would plan a certain minimum production; then if sales forecasts proved to have been conservative, additional production would be scheduled following completion of the initial orders. If not, then the productive capacity would be diverted to other products where demand was increasing, or production would be curtailed.

Generally speaking, no major re-design of production methods would be expected to accompany any increase in demand. This may have been because re-tooling for larger productive capacity might well take more time than could be permitted before orders would need to be filled. However, it might, of course, have some influence on production planning for next year.

It appeared that the character of the demand curves for their products might vary considerably, but that at any one time, while production planning was being completed, its character was essentially downward sloping, and probably not linear. It also appeared that the average cost curve was probably also downward sloping, at least until near capacity production was reached. From that point on, the marginal cost curve probably rose rapidly as production increased.

In order to answer the question, the following linear and non-linear cases were developed, using hypothetical data. The linear case was presented first in order to illustrate the most simplified conditions, and the non-linear case developed for the following period. All members of the training group showed a great deal of interest in it, and stated that they could develop their cost curve; but they displayed an equally strong feeling that the sales forecasts they received were almost never sufficiently accurate to use.

It appeared that the discussion at least partially clarified their thinking, and perhaps verified their feelings concerning the effects of production at over-capacity levels in decreasing profit. However, it was felt that the material was not generally essential in the conduct of the training program, and therefore it was not included in the training manual.

Table 1. Price-production determination under simplified (static) conditions (linear)

Sales-Production Schedule

Unit Price	Number Sold	Total Revenue	Additional Revenue	Marginal Revenue
$10	1	$10		
9	2	18	$ 8	$ 8
8	3	24	6	6
7	4	28	4	4
6	5	30	2	2
5	6	30	0	0
4	7	28	-2	-2
3	8	24	-4	-4
2	9	18	-6	-6
1	10	10	-8	-8

Cost Schedule

Number Produced	Average Cost	Total Cost	Additional Cost	Marginal Cost
1	$ 1	$ 1		
2	2	4	$ 3	$ 3
3	3	9	5	5
4	4	16	7	7
5	5	25	9	9
6	6	36	11	11
7	7	49	13	13
8	8	64	15	15
9	9	81	17	17
10	10	100	19	19

In the Sales-Production Schedule above, it has been assumed that for each given unit price, the customer demand would permit sales as indicated.

In the Cost Schedule above, it has been assumed that average costs will increase uniformly with increased production, thus permitting straight-line (linear) graphical analysis.

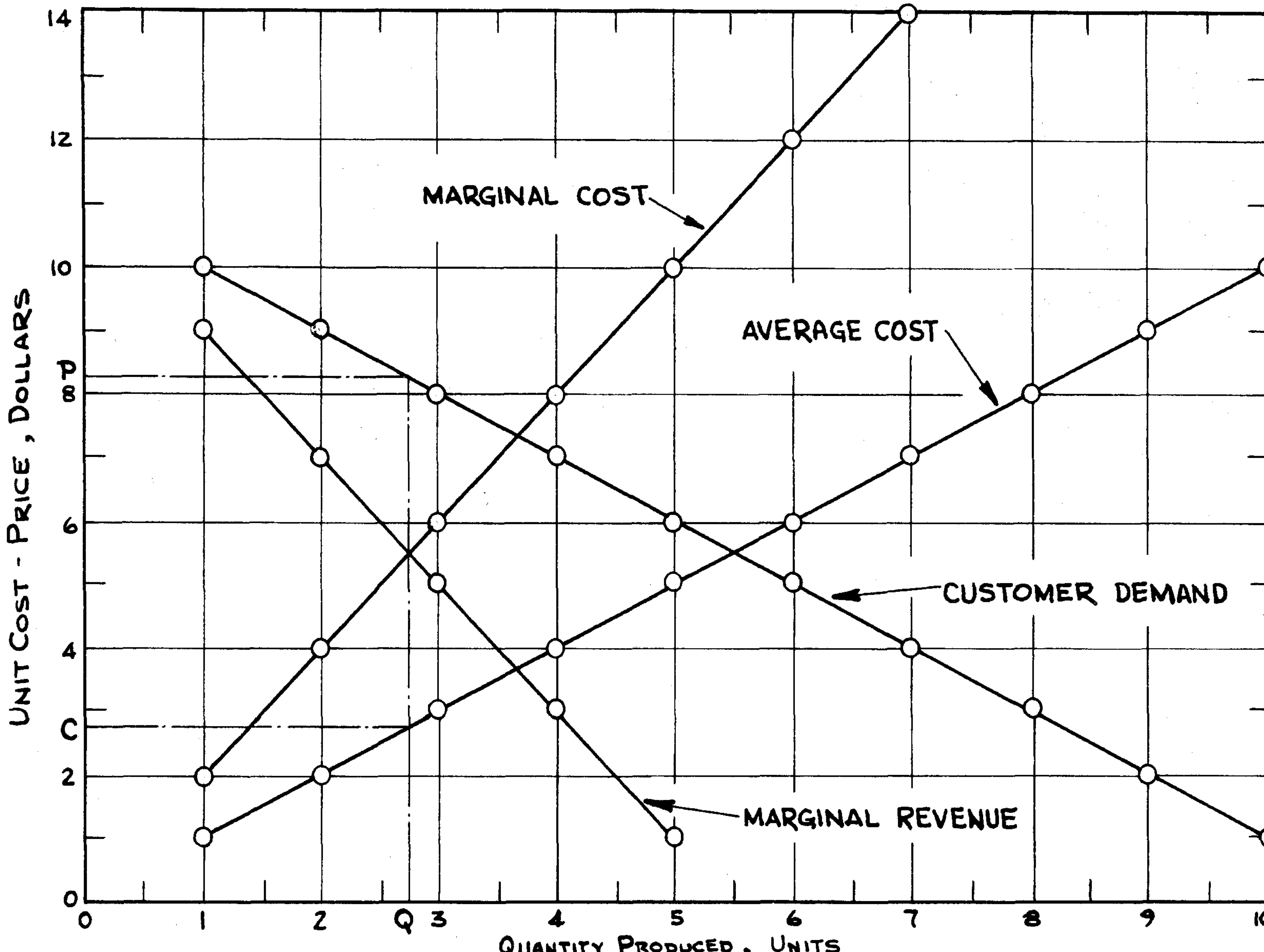

FIG.16. PRICE - PRODUCTION DETERMINATION UNDER SIMPLIFIED CONDITIONS (LINEAR).

Table 2. Price-production determination under static conditions (non-linear)

Sales-Production Schedule

Unit Price	Number Sold	Total Revenue	Additional Revenue	Marginal Revenue
$15	0	$ 0		
14	1	14	$14	$14
13	3	39	25	12.50
12	6	72	33	11
11	10	110	38	9.50
10	15	150	40	8
9	21	189	39	6.50
8	28	224	35	5
7	36	252	28	3.50
6	45	270	18	2
5	55	275	5	0.50
4	66	264	-11	-1

Cost Schedule

Number Produced	Average Cost	Total Cost	Additional Cost	Marginal Cost
0	$ 0	$ 0		
5	10	50	$50	$10
10	6	60	10	2
15	4.60	69	9	1.80
20	4	80	11	2.20
25	4.25	106	26	5.20
30	5	150	46	9.20
35	6.50	227.50	77.50	15.50
40	8	320		

In the Sales-Production Schedule above, it has been assumed that for each given unit price, the customer demand would permit sales as indicated.

In the Cost Schedule above, it has been assumed that average costs will be as indicated for the varying amounts produced. Overtime labor charges, premium cost material, and bottlenecks resulting from over capacity production are assumed to result in an increasing average cost for the higher production levels.

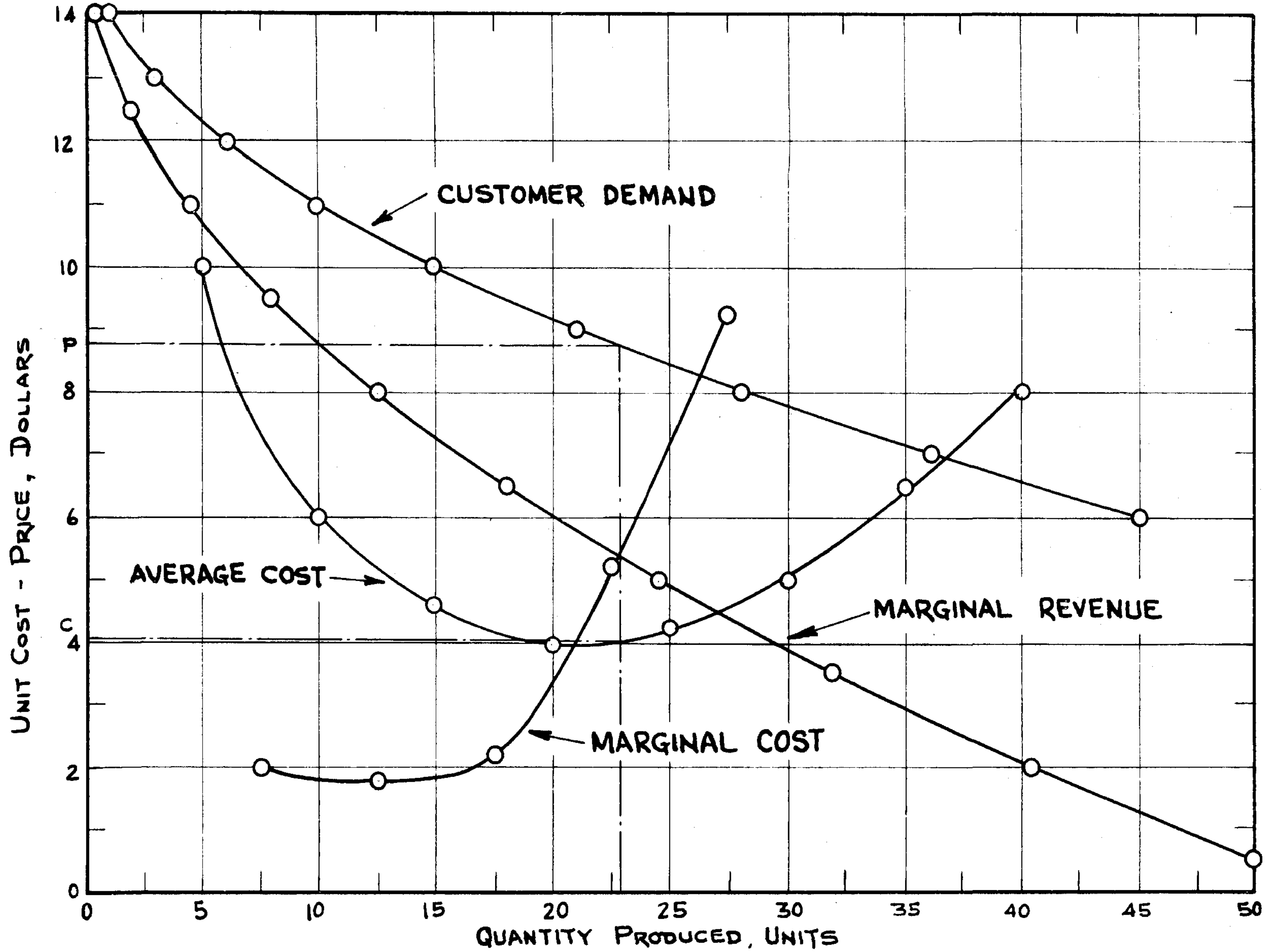

FIG. 17. PRICE-PRODUCTION DETERMINATION UNDER STATIC CONDITIONS (NON-LINEAR).

Derivation of the economic lot quantity formula was considered for inclusion in the training program. The training group was asked whether they were familiar with the calculations. Several men said that they were; but that they felt that it had had no useful application for the past 12 years. They explained that governmental controls and shortages had caused them to buy whatever material they could, and then process it as fast as it was received.

In the other training group, although some of the men claimed familiarity with it, they watched it with interest; but at its conclusion, indicated that they felt it was a factor over which they had no effective control. They said that their plant had been operating at capacity level for a long time, and they were plagued with a shortage of materials almost continually. The watchword had become "to buy as much material as they could get, especially of steel; and as soon as it was delivered, to fill as many of the more urgent orders as they could".

Other factors which the men mentioned as further indications of its limited application were: Machine breakdowns were too frequent, and often necessitated shifting the production of many machines. Also, that orders from top management frequently disrupted the planned production schedules. The trainees felt that some of this difficulty could be taken care of by improved methods of accumulating the extra cost which each interruption occasioned. Here the training program could help. But for the present, it (Economic lot determination) remained a part of the theory which could only apply when other factors ceased to exert any pronounced influence.

These two plants, selected for experimental testing of the training program, were not a randomly selected sample. On the contrary, they were carefully selected as companies which would probably have problems which might be described as typical of those facing management in smaller industrial concerns. If a statistical analysis were contemplated, not only would it be necessary to secure a much larger sample for testing the training program, but it would also be necessary to secure cooperation in gathering cost information from another group of plants which would not receive the training. It was felt that simple comparisons of cost of training and estimates of the reduction in cost which resulted would be the best practical measure of the effectiveness of the training program. Since there were so many factors which influenced the success of the training program, accurate measurement of them would be extremely difficult and expensive in terms of time and money, requiring the active cooperation of many industrial concerns.

However, even if it was not practicable to embark upon such extensive tests, it appeared that the program could be successfully applied to other concerns, and perhaps, expanded in scope to include problems in advertising, maintenance, personnel administration, wage administration, and many other problems which management must face.

A number of factors contributed toward the success of this training program. The program enabled members of "middle" or operating management to get a new perspective of the overall operations of their organization. This may have resulted, in part, from temporarily taking them away from their normal duties so that they were able to view problems with a different perspective. A portion of its success could also be attributed to stimulation resulting from the many different viewpoints expressed by members of the groups during analysis of problems.

Without a doubt, the individual technical skills of the members of both groups contributed much to the effectiveness of the training programs. The training supplied some new knowledge to members of the two groups. Instituting the program resulted in the development of new channels of communication in both of the companies. These channels of communication enabled the groups, functioning similarly to committees, to be utilized as special management devices, with the power to act in joint ventures. It also provided them with an improved position with respect to the problems inherent in initiating operating changes. The active support which top management in the companies displayed toward their training program was also a factor which contributed to its success.

To some extent, the success of the program may have been due to use of an "outsider" to lead the groups. This eliminated one possible source of friction; the chance that personal prejudices among members of the group might limit the cooperation among departments, and imperil the success of the training. It was necessary that the program director be well trained in both the primary areas included in the manual, and in related topics which could reasonably become important in the solution of particular problems.

It would be very difficult, if not impossible, to determine the amount that each of the above factors contributed toward the reduction in costs on projects which were initiated by the two training groups during the period when the training program was being experimentally tested. However, realizing that many influences were present, and that only some of them could be directly attributed to this training program, the following table (Table 3) has been prepared, listing the reductions in cost which have been estimated for projects initiated during that period. In all of these projects, it is well to note that value has either been maintained or improved while costs were reduced. Projects initiated since completion of the training have not been included in the table or totals.

Table 3

Summary of Savings Made and Costs of the Training Programs

Projects	Total Savings	Total
Christmas Tree Holder (1954)		
Reduction in cost (preliminary estimate)	$37,500.00	
Estimated expenses of project	7,500.00	
Net cost reduction (preliminary estimate)	$30,000.00	
Packaging Window Frames (annual)		
Reduction in cost (estimate)	$738.00	
Estimated expenses of project	300.00	
Net cost reduction (estimate)	$438.00	
Efficiency Report (annual)		
Reduction in cost (estimate)	$2,964.00	
Estimated expenses of project	15.00	
Net cost reduction (estimate)	$2,949.00	
Home Barrow (1953)		
Reduction in cost (estimate)	$2,167.00	
Estimated expenses of project	400.00	
Net cost reduction (estimate)	$1,767.00	
Total reduction in cost		$35,154.00
Company cost (both companies)		
Man-hours spent by members of the two training groups		
Estimated not to exceed	$1,000.00	
Training Director (if the work had been conducted on a commercial basis) (Two training programs)		
Estimated not to exceed	$1,000.00	
Total expenses		$2,000.00
Estimated net reduction in cost		$33,154.00

VII. CONCLUSIONS

The results of this investigation indicate that within the limits of the experimental testing of the training program, the following conclusions are valid:

1. Smaller industrial concerns may benefit financially by use of the training program.

2. The training can be effectively undertaken within the plant, and without the use of elaborate training aids.

3. Personnel with widely varied training and experience backgrounds are able effectively to participate in the same training group.

4. It appears to act as a "catalyst" in securing improved inter-departmental cooperation by those participating, and it furnishes a definite procedure which facilitates effective use of personnel in the problems investigated.

5. The results secured may be attributed to the following factors, some of which are a direct result of the training; others are contributing factors.

   a. The stimulation of group action.

   b. Technical skills of individual members of the groups.

   c. New knowledge for members of the groups.

d. A new perspective for members of the groups.

e. New channels of communication within the companies.

f. Use of an "outsider" to lead the training.

g. Active support from top management.

h. Greater facility in initiating operating changes.

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